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ABSTRACT

The role of 48 liberal arts colleges in the training of American scientists was studied, with attention to undergraduate/graduate education and research and development (R&D). It was found that the leading liberal arts colleges rank at or near the top of all U.S. institutions in the training of scientists. Whereas universities have seen an erosion of student interest in science in the past 7 years, the leading liberal arts colleges continue to sustain student interest in science, due to one-to-one teaching by senior scientists and a close link between teaching and research. The liberal arts colleges have functioned largely without federal support for science. Recommendations are offered concerning early student preparation in science, programs and curriculum, funding, and renewal. Data are included on: freshmen interest in the basic sciences by discipline, 1975 to 1984; bachelors and doctoral degrees for mathematics and science disciplines; scholarly activity of science faculty by discipline; science course offerings by discipline, level, and tenure status of professor; science expenditures; R&D by type of activity and sources of funding; and enrollment of freshmen in science and math for public and private two- and four-year colleges, and universities. The 48 colleges are identified. (SW)

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THE FUTURE OF SCIENCE AT LIBERAL ARTS COLLEGES

A CONFERENCE HELD AT
OBERLIN COLLEGE
JUNE 9 and 10, 1985

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EDUCATING AMERICA'S SCIENTISTS:

The Role of the Research Colleges

by

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Provost

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A Report for the Conference on "The Future of Science at Liberal Arts Colleges" held at Oberlin College, Oberlin, Ohio on June 9-10, 1985

May 1985

Office of the Provost
Oberlin College
Oberlin, Ohio 44074

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Introduction

This paper was prepared for participants in a conference on "The Future of Science at Liberal Arts Colleges" held at Oberlin, Ohio, June 9-10, 1985. The goals of the conference were to enable presidents of nearly fifty four-year colleges of arts and sciences to assess the state of teaching and research in science at their institutions, to appreciate the significance of such work to higher education as a whole and to our national life, to estimate the resources necessary to preserve and enhance this national resource, and to suggest means of attracting such resources.

The following report is based upon data gathered from forty-eight colleges of the liberal arts and sciences— the same institutions whose presidents participated in the conference itself (see p.5). These schools were selected on the basis of a composite of several objective measures of productivity in training and research in science. Obviously, there are many liberal arts colleges in addition to those contributing to this study that have distinguished themselves in one area or another of scientific work. While the conference list cannot be exhaustive, it nonetheless represents a good, objective sampling of liberal arts colleges with the most sustained commitment and achievement in the natural sciences.

So vast an agenda as the one for this conference required formidable background data. That so little of the needed information was publicly at hand may reflect the tendency prevailing nationally to underestimate the significance of liberal arts colleges in the preparation of scientific manpower in America. In spite of much research, it has not been possible to fill all of the voids in data. Consequently, a few indices are lacking comparative data between the liberal arts colleges and research universities. Obviously, it would be desirable if such information could be more systematically gathered and monitored in the future.

What do the data reveal? Broadly speaking, they show that leading liberal arts colleges rank at or near the top of all American institutions of higher education—including multiversities and major centers of research—in the training of scientists. They show that this success is due significantly to the close link between teaching and faculty research that exists on such campuses. They show that the premier colleges have been nearly immune to the erosion of student interest in science that has recently afflicted major research universities and the nation. Finally, they show that this record of accomplishment has been financed mainly by the institutions themselves and by tuition payments, the level of federal support going to science programs in liberal arts colleges having diminished even as support

for university centers has grown. In other words, this report indicates that leading liberal arts colleges are not only exceptionally productive in the natural sciences but also relatively cost effective.

To acknowledge these points is in no way to diminish the significance of the research universities. Indeed, the relationship between major universities and the colleges treated in this study is a close one, with benefits flowing in both directions. Support for university-based science is a national necessity, but investment in science at major liberal arts colleges is no less urgently called for. Such "research colleges" constitute a major component of the scientific enterprise in the United States.

S. Frederick Starr

Acknowledgments

Many people have contributed to the preparation of this report. To them we owe our gratitute. S. Frederick Starr, President of Oberlin College, launched our inquiry, maintained a clear and firm vision of its essence, and helped refine it through the fires of revision. Our list of indebtedness is a long one. Many persons at Oberlin and across the nation contributed time, energy, and talents. The Presidents and staff members of the participating institutions spent may hours compiling the data for our survey. Since a study such as this had previously not been done, the collection of data required great patience and diligence.

Faculty members from the Oberlin College science departments generously gave of their time and energy to offer suggestions and bibliographical citations in response to our never-ending queries. We want to express our appreciation to Martin Ackermann, George Andrews, David Benzing, Norman Craig, Samuel Goldberg, Norman Henderson, Joseph Palmieri, and William Skinner.

Marny Muir and Conrad Stanitski took time out from their American Council on Education Fellowship year to contribute important studies on the preparation of pre-college students in science and science doctorate production for the set of 48 colleges. Other individuals who provided us with valuable and often unpublished statistics were Ida Wallace and Karen Davis from the Independent Colleges Office, Thomas Snyder from the National Center for Education Statistics, and Carol Fuller from the Great Lakes Colleges Association, whose extensive study on Ph.D. production was invaluable. Two student assistants, Melanie Bernhardt and Eric Phillips, spent untold hours entering and analyzing data. Constance Gardner tabulated financial data from the survey.

When it was time to write recommendations for the needs of current and future science programs, we approached faculty members from a wide variety of undergraduate institutions. From this dedicated group of scientists came a series of drafts which clearly delineated the needs of biology, chemistry, computer science, geology, mathematics, and physics. Their contributions are published as a separately-bound document. For this faculty perspective of science at liberal arts colleges we are indebted to Neal Abraham, H. Robert Burger, Norman Craig, Stuart Crampton, Eleanor Lonske, Jerry Mohrig, Peter Patton, Bruce Peterson, Jeanne Powell, Stanley Selkow, John Watkins, and William Zimmerman. At Oberlin, Associate Provost David Love and Dean Alfred MacKay offered many constructive comments on the recommendations portion of the report.

The seven college Presidents who convened the science conference for which this report was produced, have patiently and persistently read drafts, offered comments, and willingly taken on numerous tasks which enabled us to finish this project. For this we thank Paul Bragdon, John Chandler, Robert Edwards, David Fraser, Elizabeth Kennan, James Powell, and Frederick Starr.

Finally, we thank the administrative support staff at Oberlin who put up with our innumerable phone calls, untold drafts and revisions, and endless correspondence. With the help of Lyn Boone, Evelyn Campbell, Cathy Lang, Jane Nabakowski and Linda Robinson this report slowly but surely became reality. Barbara Chaisma and Mary Ann Anderson guided the report through the final process of design and printing.

To more persons than we have listed here we owe a great debt of thanks. As authors we share with these individuals a deep and abiding commitment to a liberal arts education. Our own respective baccalaureate institutions, Wesleyan University, Carleton College, and Calvin College convinced us long ago of the vital resources that liberal arts colleges represent for the scientific enterprise in this country.

Oberlin, Ohio
May, 1985

Sam C. Carrier
David Davis-Van Atta
Frank Frankfort

The Future of Science at Liberal Arts Colleges

Conference Participants
Oberlin College
June 9 and 10, 1985

Albion College
Alma College
Amherst College
Antioch University
Barnard College
Bates College
Beloit College
Bowdoin College
Bryn Mawr College
Bucknell University
Carleton College
Colgate University
Colorado College
Davidson College
Denison University
DePauw University
Earlham College
Franklin and Marshall College
Grinnell College
Hampton University
Harvey Mudd College
Haverford College
College of the Holy Cross
Hope College
Kalamazoo College
Kenyon College
Lafayette College
Macalester College
Manhattan College
Middlebury College
Mount Holyoke College
Oberlin College
Ohio Wesleyan University
Pomona College
Reed College
Smith College
St. Olaf College
Swarthmore College
Trinity College (Conn.)
Union College
Vassar College
Wabash College
Wellesley College
Wesleyan University
Wheaton College (Ill.)
Whitman College
Williams College
College of Wooster

Chapter I

The Demography of Student Interest and Degree Production in the Basic Sciences in America

"I consider my undergraduate training at a liberal arts institution as the single most important element in my education. All the relevant factors were there: High-quality, conscientious faculty, who taught with dedication; fellow students of the highest ability with whom to share ideas; a broadening and stimulating liberal arts atmosphere in which one learned to appreciate the philosophical and social ramifications of one's discipline; and, above all, an institution which fostered the highest idealism and honesty toward the academic enterprise, toward science, toward the proper role of science in human experience, and, indeed, toward human conduct in the broadest sense."

— Sandra M. Faber, Professor of Astronomy and Astrophysics, Univ. of California, Santa Cruz (Swarthmore)

America's continued leadership in world science and technology depends on a steady supply of highest-ability, fully trained scientific minds flowing from the nation's undergraduate and graduate institutions of higher education. Throughout the 1950's and 1960's, this supply was abundant as the total number of students entering college rose rapidly, and greater numbers and proportions of undergraduates subsequently pursued graduate degrees. The scientific disciplines rode these tides and those created by national conditions such as the space race and the emergence of electronic data processing. The absolute numbers of degrees awarded at all levels in all disciplines of the basic sciences increased by as much as fourfold between 1950 and 1970.

However, recent national trends indicate potentially serious threats to the continued supply of top-quality scientists:

* Nationally the percentage of all freshmen indicating intention to major in the basic (i.e., unapplied) sciences has fallen precipitously from 10% in 1975 to 6.6% in 1984, a 33% decline in nine years (Table I).

* Because the total number of new freshmen also declined over this period, the absolute reduction in raw numbers of prospective science students has been even greater: a 38% decline in nine years.

* This decline has occurred at every type of institution of American higher education: two-year and four-year schools, colleges and universities, public and private, from highly selective to unselective (Table II).

* The decline in science students has affected equally the four-year colleges (-38%) and all universities (-39%), and has been significantly greater than the national average decline for both, particularly those privately controlled, -40% and -45% respectively.

* This aggregate decline in proportional interest in basic science is actually the result of significantly reduced interest in every individual discipline within the sciences (Table III). All biological sciences, all physical sciences, mathematics, and statistics have experienced serious reduction during the past decade in proportional interest among American freshmen.

* While the average national scores on the Scholastic Aptitude Tests declined only slightly between 1978 and 1983 (four points on the verbal mean and not at all on the mathematical sub-score), both the verbal and the mathematical means of students intending majors in the basic sciences continued to fall (Table IV). In all science disciplines, the drop in the mathematical mean has been greater than that of the national trend. Significant and increasing numbers of the brightest students appear to have been indicating prospective majors in non-science fields.

* As a consequence, degree production at all levels has declined seriously. Annual totals of both baccalaureate and doctoral degrees in all basic science fields (except for doctorates in biology and all degrees in geology) peaked in the early to mid-1970's (Tables V.A. and V.B). From these high points, total numbers of degrees awarded at each level have been decreasing more or less rapidly for specific disciplines. The number of baccalaureate degrees conferred in all basic sciences fell 17.4% from 1975 to 1981. The number of doctoral degrees awarded dropped 8% over this period and 21% since 1970. Science bacculaureates fell from representing 9.4% of all bachelor's degrees to 7.7%, a -23% change between 1975 and 1981.

* Mathematical fields in particular have been severely affected: shrinking fully 60% in the total number of baccalaureate degrees and 41% in doctorates awarded. Physics ranks a close second, falling 35% and 40% in baccalaureates and doctorates respectively, between 1970 (the peak year for both disciplines) and 1981.

The last half of the 1970's accounted for most of the loss in undergraduate prospective interest in the sciences. This decline has continued through the first half of the 1980's at a slower rate. However, this reduction in the rate of decreasing interest is of limited consolation. The facts remain that freshman intention to major in the basic sciences:

** is very low nationally, barely more than 5%;
** has fallen sharply in the past decade, by nearly 40% in absolute numbers since 1975;
** is still falling.

As a result, degree production at all levels in most disciplines of the basic sciences has recently declined significantly. The conditions for mathematics are most critical, with physics a close second.

An Alternative to Decline: The 48 Liberal Arts Colleges

In contrast to these ominous national trends stands a selected set of 48 relatively small, independent, four-year colleges of the liberal arts and sciences. These highly selective, distinguished institutions:

* annually enroll freshman classes with very high proportional interest in science;

* have not been ravaged by the recent national decline in freshman interest in basic science that has affected every other general institutional type;

* have continuously produced outstanding graduates, with unusually high proportions earning majors in the sciences and equally unusually high proportions of graduates subsequently going on to the doctorate and careers in scientific fields.

Following are the primary statistics on the vitality of the basic sciences at these 48 colleges.

* 28% of their freshman intented to major in the sciences in 1984; this is four times the national average of 6.6% (Table VI, Graphs I and II).

* This proportion is twice the level of science interest (14%) at their set of peer-group institutions (all four-year, private, non-sectarian colleges of high and very high selectivity.)

* Most important, the 28% proportion of prospective science majors at the 48 colleges is nearly double that for all highly selective private universities (17%), and more than double the 12% proportion at public universities of high selectivity, the institutions often, but mistakenly, considered to be the highest per capita producers of American scientists.

* The 12% decline in proportional interest in the basic sciences experienced by the 48 liberal arts colleges from the mid-1970's to 1984 (from 31.8% in 1976 to 27.8% in 1984) was minimal, but not negligible, and appears excellent when compared to the national trend during this period. Their 9% loss in absolute numbers compares even more favorably.

* The 48 colleges' 12% proportional decline is even more positive when contrasted with the -34% change in proportional interest in the sciences at the highly selective private universities, and with the -36% change at highly selective public universities over this period. The change at their peer group colleges was -33%. Again, the 9% absolute loss at the 48 liberal arts colleges is minimal in contrast to these reference groups.

* No individual scientific discipline (except geology) at these 48 liberal arts colleges has experienced a reduction in absolute or proportional freshman interest nearly equal to that which occured nationally and at the highly selective private universities (Table VIII).

* The percentage of all graduates from these colleges earning degrees in the basic sciences has held steady at 24% from 1975 through 1983 (Table IX). Thus, these colleges have not contributed to the national decline in science baccalaureate production, but have consistently graduated students earning such degrees in much greater proportion than either the nation's colleges and universities as a whole (only 7.7% in 1981) or, more importantly, than those public and private U.S. research universities that are top-rated by the National Academy of Sciences (Appendix B), only 14% (1980).

* The absolute numbers of science baccalaureates awarded by these colleges over this period actually has risen sharply, by 16%, whereas there has been serious shrinkage nationally, and at the 20 top-rated universities, a reduction of 14% in numbers of science graduates from 1976 to 1980 alone.

* Their aggregate, and many of their individual, per capita production of graduates going on to earn doctorates is significantly greater than that of several different sets of major American research universities (Table XI).

The Role of the Liberal Arts Colleges in Science in America

The above data can only mean that the role played by these 48 distinguished colleges of the liberal arts and sciences in the undergraduate training of American scientists has recently expanded significantly, even beyond its historically vital place.

* While freshman intention to major in the basic sciences has fallen dramatically, both nationally and in the major public and private research universities, it has fallen minimally by comparison at the 48 liberal arts colleges. Thus, these colleges are attracting, enrolling and educating a significantly increasing share of the prospective science market.

* Between 1976 and 1984, their share of this market has risen 32%, from enrolling 32.9 per thousand science prospects nationally to 43.4 per thousand. This share has risen, to varying degree, in every individual discipline of the basic sciences (except geology) (Table XII).

* Even more important, however, is the comparison of the role of these 48 colleges to that played by the highly selective private universities. In these two years, the aggregate share of the U.S. freshman science market enrolled by these prestigious universities is only slightly larger than that of the 48 colleges. That is:

  ** these 48 liberal arts colleges are every bit as essential to the preparation of American scientists as are the best private research universities;

  ** while the university share grew 23% over this past decade, the colleges' share grew more, 32%. The role of these colleges in American science education is expanding absolutely, and expanding relative to the major universities.

While freshman interest in science is crucial, the tangible output measures are equally important. Here too, the story is similar (Table XIII):

* While national baccalaureate production in the sciences in general has decreased significantly since the early 1970's in both absolute numbers and proportion of total bachelor's degrees, the 48 liberal arts colleges have consistently graduated a 24% proportion in science, and the absolute number of bachelor's degree has risen 16% from 1975 to 1983.

* Again, this can only mean that the historically vital role played by these liberal arts colleges in the undergraduate training and production of American scientists is growing

even more important. Their share of total U.S. baccalaureate production grew 27% between 1975 and 1980 alone, from graduating 42.5 per thousand science bachelors nationally to 53.7 per thousand.

* Their share, and their absolute numbers, grew in every discipline (except share in geology and, minimally, numbers in biology).

* And again, relative to a set of major American research universities (those 20 with graduate programs top-rated in the National Academy of Sciences ranking), the colleges' role has expanded significantly.

* While these universities' share of U.S. science baccalaureate production grew only 1% between 1976 and 1980, and fell 14% in absolute numbers, the 48 colleges' share grew 27% and numbers rose 8% between 1975 and 1980.

However, in spite of these very positive statistics on the essential and expanding role of the liberal arts colleges in the preparation and production of American scientists, there are diametrically opposing conditions and trends in the national funding of science research and education. These are detailed in Chapter III of this report. Suffice it to say here that the influx of monetary support to these vital colleges from all sectors of scientific support in America is minuscule and, since 1978, has fallen precipitously while monetary support to universities has risen in direct opposition to their declining role in undergraduate science education. If these conditions persist there will be serious erosion of the vital role of these colleges in science in America.

The Liberal Arts Colleges: Essential to American Science

The liberal arts colleges as a group have long been known to be the highest per capita producers of graduates going on to earn doctorates in scientific fields. Even so, this fact has not been widely recognized:

> "Asked where U.S. scientists come from, the average person would probably say that they flow mainly from the major centers of American intellectual activity and are prepared predominantly in our great universities and special scientific schools. The facts say otherwise . . . small liberal arts colleges are far and away the most productive sources of future scientists among U.S. institutions. Of the 50 leading institutions in this respect (i.e., those that turn out the largest proportion of graduates who become scientists), 39

> are small liberal arts colleges. Only three large universities even appear on this list of leaders, and only two technical institutions . . . " (Goodrich, Knapp and Boehm, 1951)

It is clear from the data presented in this chapter that these 48 liberal arts colleges, selected among peers to be those most distinguished with respect to undergraduate science, are an invaluable national resource, particularly given current national trends. They rank far above national, peer group, and research university means in both proportional interest in the basic sciences among freshmen and in proportional production of science baccalaureates. They have been relatively unaffected by national trends of the past decade in both student interest and baccalaureate production in these fields.

> It is reasonable to speculate that it would be extremely difficult to assemble any other set of colleges, identified on the basis of some alternative, independent criteria, which would subsequently be found to boast the conditions and trends with respect to undergraduate basic science claimed by this unique set of schools.

The strong and stable attraction of high-ability science students to these 48 liberal arts colleges, and their stable, large-volume production of science graduates in all fields, anomalously high percentages of whom go on to earn doctorates, distinguish these institutions among peers and universities alike and make their continued strength in the sciences essential to the steady supply of the best scientific minds for America's present and future. These institutions are all the more important now given nationally declining enrollments, seriously diminished intention to major in the sciences at the undergraduate level, the generally decreasing numbers of degrees conferred in basic science at all levels, and the steadfast resistance of these colleges to <u>all</u> these trends.

The continued supply of scientists is vital for many reasons, chief among them being that the progress of all applied science and technology depends directly on the advances made by basic science. While negative growth has occurred in the basic sciences, the opposite has taken place with most applied science areas. For example, engineering, in aggregate as well as by specific area, and computer science have experienced rapid growth, both as prospective majors among American freshmen since 1975 and in numbers of degrees earned, primarily at the undergraduate level, since the mid-1970's.

Individuals with such applied training and career aspirations may be in great demand now, and for the foreseeable future. However, without the foundation of significant human and capital resources dedicated to basic science and research, continued progress in the applied sciences and technology will quickly and dramatically be slowed. It is basic science, and often unapplied research, which historically has led to many of the great discoveries and developments (and to those not great but still vitally important) which fuel the subsequent achievements of applied science and technological development.

Issues for the Future

These data clearly raise a variety of issues of national concern:

* How can the supply of future scientists of top quality be assured as enrollments drop? How will students, particularly those of high aptitude, be attracted to majors and careers in the basic sciences in numbers sufficient to off-set the demography during the remainder of this century? This will require not merely halting but substantially reversing current trends.

* How will the education of such students be funded?

* How will opportunities for research, an essential part of the education of all scientists, be made available at the undergraduate level in increased numbers?

* How will basic science and research in America be funded?

* What will be the supply of excellent, inspiring science faculty for both undergraduate and graduate education? Given the high demand and relatively short future supply of scientists, what can be done to ensure that careers in science education will be competitive with other options both professionally and financially?

* What can be done now in secondary and even primary education to stimulate and prepare the next student generations to elect careers in the sciences?

The answers to these and other such questions are essential to the future of a rapidly more technological American society and world economy.

One cornerstone in these solutions at the undergraduate level will be these 48 private colleges of the liberal arts and sciences.

These institutions historically have held great attraction for, and been significant producers of, high-ability scientists. They are an indispensable national resource for responding to present and future demands for scientific mind-power.

To date, these institutions have resisted the national trends with great success. Nevertheless, they, too, exhibit certain conditions which indicate the need to address immediately a variety of their own policy issues:

* How will these institutions continue to enroll an ever increasing share of the high-ability prospective science market? Already, these schools have experienced some reduction in proportional interest in science among their freshmen, particularly in geology and chemistry and, to a lesser degree, in the biological sciences (Table VII).

* Can a greater percentage of those freshmen initially intending to major in the sciences (approximately 30%) be nurtured through to graduation with such a degree (approximately 25%)? At present, there exists a net out-flow from the sciences, even after accounting for institutional attrition.

* How would increased student demand be met by the the institutional resources of faculty? modernized laboratory space? more and new scientific equipment, often of high cost? and the other aspects of direct and indirect academic support?

* How will these needs be funded adequately during an era of potentially serious reduction in enrollments and one of restricted internal resources?

* How will these colleges, and the nation, respond to the rapidly growing proportion of women in the sciences (Tables XIV and XV)? It has been the growth in women's interest in science which alone has sustained both overall freshman interest and baccalaureate degree production in the basic sciences at these schools. By 1979, women had come to represent a majority (52%) of all science graduates.

The data describing these national conditions and those of the 48 liberal arts colleges have been detailed in this first chapter of this report. Chapter II will present information concerning the educational process of scientists, with particular attention paid to their education at the liberal arts colleges. These data indicate the reasons behind the documented, significant success of these institutions in science education. The third chapter studies the information on national funding of scientific research and development in the United States, including that conducted in the education sector. Here again, particular attention is given to data on the internal and external support of basic science education and research at the 48 liberal arts colleges.

In these and the fourth chapter, a set of recommendations, some appropriate and effective responses to the above questions are put forth. However, these issues remain open ones, requiring the earnest and immediate attention of persons in the educational, governmental, foundational, and industrial sectors that are entrusted with assuring the vitality into future generations of these unique, invaluable institutions.

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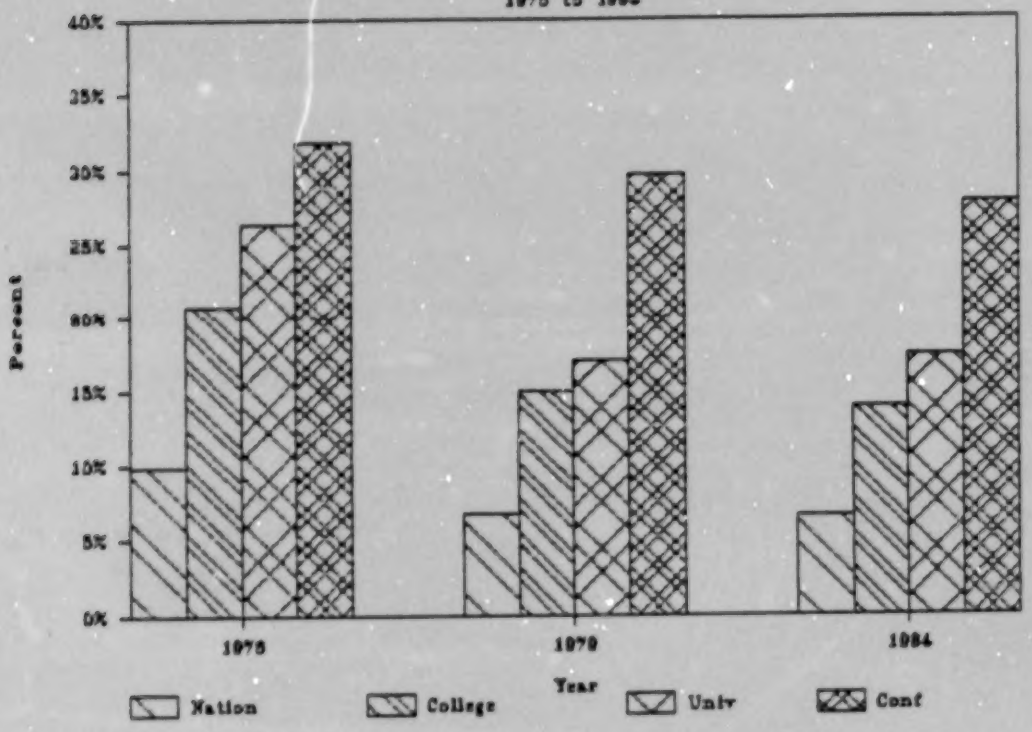
Graph I

Freshman Interest in Science

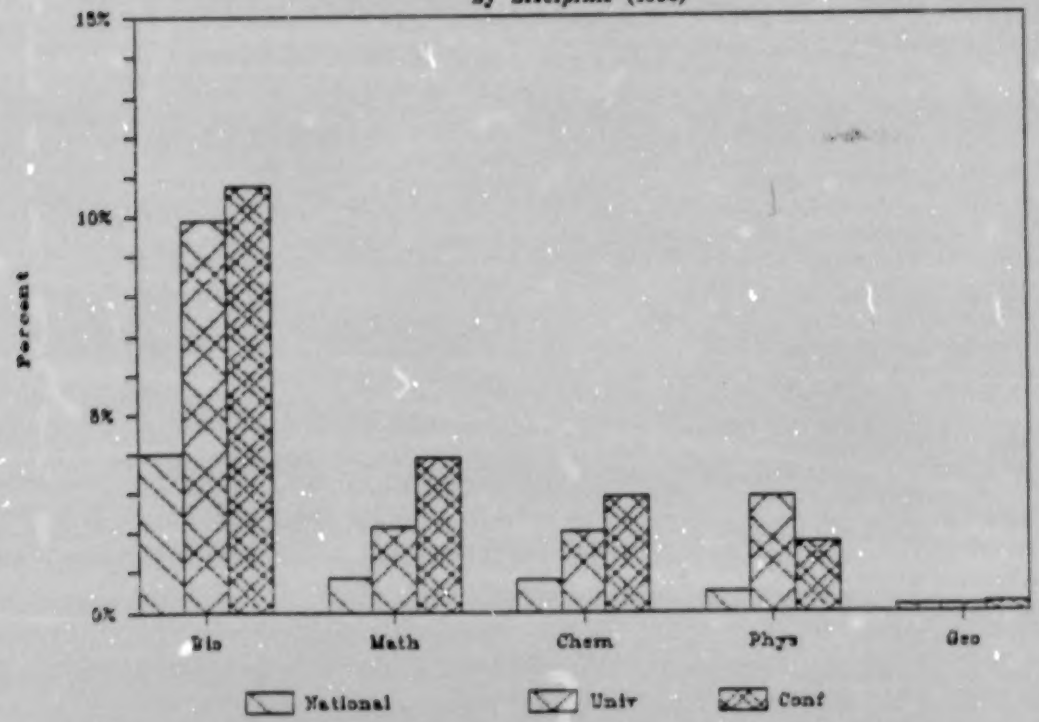
1975 to 1984



Graph II

Freshman Interest in Science

By Discipline (1984)



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I. Absolute and Proportional U.S. Freshman Interest In All Basic* Sciences: 1975, 1979 and 1984

Year of Enrollment	N of Freshmen**	N Basic Science	% Science	% Change from 1975 N Sci.	% Change from 1975 % Sci.
1975	1,760,530	174,721	9.9%	--	--
1979	1,713,144	116,396	6.8%	-33.4%	-31.5%
1984	1,635,221	108,499	6.6%	-37.9%	-33.1%

Notes : 1. From 1975 to 1984, absolute numbers of all freshmen intending to major in one of the basic sciences have declined 37.9%.

2. This translates as a 33.1% decrease in the proportion of U.S. freshmen intending science majors, from 9.9% to 6.6%.

3. The period of most rapid decline occured from the mid to late 1970's, but has continued to date (at a slower rate).

Sources : The American Freshman: National Norms, 1975, 1979 and 1984, American Council on Education and The Cooperative Institutional Research Program of the University of California at Los Angeles (See tables of Appendix A for details)

* i.e., unapplied sciences. Throughout this report, basic sciences are defined as biological sciences, chemistry, earth sciences, mathematics and statistics, physics and astronomy, and, in certain cases, miscellaneous "other" unapplied sciences.

** First-time, Full-time, All U.S. institutions

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II. Absolute and Proportional U.S. Freshman Interest in all Basic Sciences : By Selected Types of Institutions of Post-Secondary Education, 1975 to 1984

Type of Institution	Year of Enrollment	N of Freshmen	N Basic Science	% Science	% Change from 1975 N Sci.	% Change from 1975 % Sci.
All 4-Year Institutions	1975	1,020,283	133,149	13.1%		
	1984	1,028,531	82,224	8.0%	-38.2%	-38.7%
All 2-Year Institutions	1975	740,247	41,572	5.6%		
	1984	606,690	26,276	4.3%	-36.8%	-22.9%
Selected 4-Year Types :						
4-Yr. Colleges	1975	618,235	72,634	11.7%		
	1984	640,048	46,614	7.3%	-35.8%	-38.0%
Universities	1975	402,048	60,515	15.1%		
	1984	388,483	35,610	9.2%	-41.2%	-39.1%
All Public 4-Year	1975	662,456	77,527	11.7%		
	1984	657,207	48,221	7.3%	-37.8%	-37.3%
All Private 4-Year	1975	357,827	55,622	15.5%		
	1984	371,324	34,003	9.2%	-38.9%	-41.1%
Low & Medium Selectivity	1975	791,377	87,857	11.1%		
	1984	803,262	53,091	6.6%	-39.6%	-40.5%
High & V. High Selectivity	1975	228,906	45,292	19.8%		
	1984	225,269	29,133	12.9%	-35.7%	-34.6%

Notes :

1. The absolute and proportional decline in freshman interest in the basic sciences has affected all types of post-secondary education.
2. The decline has been slightly greater among all universities than among all 4-year colleges, particularly in absolute numbers, and has been greater for both groups than the national average proportional decline.
3. The decrease in freshman interest in basic science has affected 4-year private education somewhat more than its public counterpart.
4. Institutions of high selectivity have been noticably less affected than have those of lower selectivities.

Sources : The American Freshman: National Norms, 1975 and 1984, (See tables of Appendix A for details)

III. Absolute and Proportional Total U.S. Freshman Interest In the Basic Sciences by Discipline, 1975 to 1984

Year of Enrollment		Biological Sciences	Chemistry	Geology	Math.	Physics
1975	N	109,274	20,692	4,645	18,705	9,650
	%	6.2%	1.2%	.3%	1.1%	.5%
1984	N	65,152	13,037	2,784	13,871	7,848
	%	4.0%	.8%	.2%	.8%	.5%
% Change 75 to 84 :	N	-40.4%	-37.0%	-40.1%	-25.8%	-18.7%
	%	-35.8%	-32.2%	-35.5%	-20.2%	-12.4%

Notes :

1. The national decline in aggregate freshman prospective interest in the basic sciences is tthe result of decreasing interest in each of the major specific disciplines, measured in both absolute numbers and as proportion of total freshmen.

2. Most affected at the freshman level have been the biological sciences and geology.

Sources : The American Freshman: National Norms, 1975 and 1984, American Council on Education and The Cooperative Institutional Research Program of the University of California at Los Angeles (See tables of Appendix A for details)

IV. National Scholastic Aptitude Test (SAT) Score Means Among High School Seniors, by Prospective College Major : All Majors vs. Science Disciplines, 1978 to 1983

Year of Freshman Enrollment	All Majors		Biological Sciences		Physical Sciences		Mathematics	
	V	M	V	M	V	M	V	M
1978	429	468	475	511	499	566	464	585
1979	427	467	472	507	498	561	459	580
1980	424	466	469	506	495	560	455	577
1981	424	466	471	504	498	558	456	572
1982	426	467	472	504	496	558	455	569
1983	425	468	473	508	496	560	453	572
Change, 1978 to 1983 :	-4	0	-2	-3	-3	-6	-11	-13

Notes :

1. While national SAT score means declined slightly on the verbal sub-score, and not at all on the mathematical sub-score, between 1978 and 1983, the SAT means of students indicating prospective majors in the basic sciences all declined greater than the national change in sum (M+V).

2. In each of the science areas, the decline in the mathematical sub-score mean has been greater than the national decline.

3. Mathematics appears to have had the greatest loss of highest-ability students.

Source : College Bound Seniors: 1972 to 1983, Tables 1 and 14 (pp. 6, 7, 45), The College Board, (New York, New York)

V. A. Volume of U.S. Earned Bachelors Degrees
By Selected Disciplines, 1962 through 1981

Discipline		Year Conferred 1962	1970	1975	1980	1981	% Change 70 to 81
Bio. Sciences	N	13,563	32,731	50,172	42,670	39,973	22.1%
	%	3.5%	4.1%	5.4%	4.6%	4.3%	4.2%
Chemistry	N	8,089	11,617	10,649	11,232	11,347	-2.3%
	%	2.1%	1.5%	1.1%	1.2%	1.2%	-16.7%
Geology	N	1,499	3,002	4,559	5,924	6,384	112.7%
	%	.4%	.4%	.5%	.6%	.7%	81.4%
Mathematics	N	14,610	27,565	18,346	11,378	11,078	-59.8%
	%	3.8%	3.5%	2.0%	1.2%	1.2%	-65.7%
Physics	N	4,812	5,333	3,716	3,396	3,441	-35.5%
	%	1.3%	.7%	.4%	.4%	.4%	-45.0%
Sci. Sub-Total	N	42,573	80,248	87,442	74,600	72,223	-10.0%
	%	11.1%	10.1%	9.4%	8.0%	7.7%	-23.2%
U.S. Total	N	382,822	798,070	931,663	929,417	935,410	17.2%
	%	100.0%	100.0%	100.0%	100.0%	100.0%	

Notes :

1. Absolute numbers of baccalaureate degrees conferred in most of the basic sciences reached maxima during the first half of the 1970's.
2. Since then, baccalaureate production in the basic sciences has decreased, in aggregate and for most individual disciplines, as measured both in absolute numbers and as proportion of total U.S. baccalaureate production.
3. Mathematics has been most seriously affected, with physics a close second.
4. The exceptions are geology and, to a lesser degree, the biological sciences (curiously, the same two disciplines exhibiting the greatest decreases in freshman interest, see Table III.)

Source : Fact Book on Higher Education, 1984-85,
The American Council on Education (Tables 145, 168-172, 186-189)

V. B. Volume of U.S. Earned Doctoral Degrees
By Selected Disciplines, 1962 through 1981

Discipline		Year Conferred 1962	1970	1975	1980	1981	% Change 70 to 81
Bio. Sciences	N	979	2,176	2,124	2,588	2,234	2.7%
	%	8.4%	7.3%	6.2%	7.9%	6.8%	-6.9%
Chemistry	N	1,139	2,208	1,824	1,545	1,622	-26.5%
	%	9.8%	7.4%	5.4%	4.7%	4.9%	-33.4%
Geology	N	208	355	387	352	424	19.4%
	%	1.8%	1.2%	1.1%	1.1%	1.3%	8.3%
Mathematics	N	396	1,236	975	724	728	-41.1%
	%	3.4%	4.1%	2.9%	2.2%	2.2%	-46.6%
Physics	N	667	1,439	1,080	830	866	-39.8%
	%	5.7%	4.8%	3.2%	2.5%	2.6%	-45.5%
Sci. Sub-Total	N	3,389	7,414	6,390	6,039	5,874	-20.8%
	%	29.2%	24.8%	18.7%	18.5%	17.8%	-28.2%
U.S. Total	N	11,622	29,872	34,086	32,615	32,958	10.3%
	%	100.0%	100.0%	100.0%	100.0%	100.0%	

Notes :
1. As with baccalaureate production, numbers of doctoral degrees conferred in the basic sciences peaked during the early 1970's.
2. Since then, doctoral production in the basic sciences also has decreased, in aggregate and for most individual disciplines, as measured both in absolute numbers and as proportion of total U.S. Ph.D. production.
3. Again, mathematics has been most seriously affected, with physics a close second.
4. Again, the exceptions are geology and the biological sciences. However, Ph.D. production in the biological sciences has declined as a percentage of total production, but has risen slightly in absolute numbers.

Source : Fact Book on Higher Education, 1984-85,
The American Council on Education (Tables 145, 168-172, 186-189)

VI. Absolute and Proportional Freshman Interest in All Basic Sciences
The 48 Liberal Arts Colleges vs. Key Reference Groups,
1975, 1976, 1979 and 1984

Year of Enrollment	The 48 Liberal Arts Colleges		Priv. Universities High Selectivity		Private 4-Year Non-Sectarian Colleges of High & V. High Selectvty.		Nation	
	N	%	N	%	N	%	N	%
1975	--	--	7,603	26.3%	10,648	20.9%	174,721	9.9%
1976	7,002	31.8%	6,852	26.4%	10,791	20.8%	176,406	9.9%
1979	6,781	29.0%	4,794	17.7%	7,269	15.1%	116,396	6.8%
1984	6,362	27.8%	5,157	17.4%	6,603	14.0%	108,499	6.6%
% Change 76 to 84 :	-9.1%	-12.4%	-24.7%	-34.1%	-38.8%	-32.8%	-38.5%	-33.0%

Notes :
1. The proportion of freshmen at the 48 liberal arts colleges intending majors in the basic sciences is higher than that of the highly selective private universities and their peer group colleges, and is much higher than the national average.

2. Since 1975, the 48 liberal arts colleges have not experienced the decline in freshman interest in science to nearly the degree that has occured at the university and college reference groups, and nationally, as measured by either absolute numbers or proportional interest.

Sources : The 48 colleges : internal survey. (See Table VII for details)
Others : The American Freshman: National Norms,
1975, 1976, 1979 and 1984 (see tables of Appendix A for detail)

VII. Freshman Interest in the Basic Sciences, 1976 through 1984
The 48 Liberal Arts Colleges
By Discplines
(Freshman Enrollments, all Institutions)

Prospective Major	1976		1979		1984		% Change 76 to 84	
	N	%	N	%	N	%	N	%
Biology	3,001	13.6%	2,523	11.0%	2,460	10.8%	-18.0%	-21.0%
Chemistry	943	4.3%	772	3.4%	658	2.9%	-30.2%	-32.8%
Geology	100	.5%	163	.7%	50	.2%	-50.1%	-51.9%
Mathematics	939	4.3%	933	4.1%	886	3.9%	-5.7%	-9.0%
Physics	432	2.0%	524	2.3%	398	1.7%	-7.9%	-11.2%
Other Sciences	1,586	7.2%	1,866	8.1%	1,910	8.4%	20.4%	16.1%
Sci. Sub-total	7,002	31.8%	6,781	29.6%	6,362	27.8%	-9.1%	-12.4%
Non-sciences	12,063	54.7%	12,401	54.2%	12,944	56.6%	7.3%	3.5%
Undecided	2,976	13.5%	3,713	16.2%	3,556	15.6%	19.5%	15.2%
Freshman Total :	22,040	100.0%	22,894	100.0%	22,862	100.0%	3.7%	.0

Source: The 48 colleges internal survey.

VIII. Absolute and Proportional Freshman Interest in the Basic Sciences by Discipline : The 48 Liberal Arts Colleges compared to Highly Selective Private Universities and National Norms, 1975/76 to 1984

Group	Year of Enrollment		Biological Sciences	Chemistry	Geology	Math.	Physics
The 48 Liberal Arts Colleges:	1976	N	3,001	943	100	939	432
		%	13.6%	4.3%	.5%	4.3%	2.0%
	1984	N	2,460	658	50	886	398
		%	10.8%	2.9%	.2%	3.9%	1.7%
Priv. Univ. Hgh. Select. :	1975	N	4,450	1,023	80	883	973
		%	15.4%	3.5%	.3%	3.1%	3.4%
	1984	N	2,931	598	47	628	856
		%	9.9%	2.0%	.2%	2.1%	2.9%
National Norms :	1975	N	109,274	20,692	4,645	18,705	9,650
		%	6.2%	1.2%	.3%	1.1%	.5%
	1984	N	65,152	13,037	2,784	13,871	7,848
		%	4.0%	.8%	.2%	.8%	.5%
% Changes, 75/76 to 84:							
48 Colleges		N	-18.0%	-30.2%	-50.0%	-5.6%	-7.9%
Universities		N	-34.1%	-41.5%	-41.3%	-28.9%	-12.0%
Nation		N	-40.4%	-37.0%	-40.1%	-25.8%	-18.7%
48 Colleges		%	-21.0%	-32.7%	-51.8%	-9.0%	-11.2%
Universities		%	-35.9%	-43.1%	-42.8%	-30.7%	-14.3%
Nation		%	-35.8%	-32.2%	-35.5%	-20.2%	-12.4%

Notes : No individual basic science discipline (except Geology) at the 48 liberal arts colleges has experienced a decline in absolute numbers or proportional interest interest among freshmen equal to that which has occured at the highly selective private universities and nationwide.

Sources : The 48 colleges : internal survey. (See Table VII for details)
Others : The American Freshman: National Norms, 1975, 1976, 1979 and 1984, (see tables of Appendix A for detail)

IX. Absolute and Proportional Baccalaureate Degree Production in All Basic Sciences : The 48 Liberal Arts Colleges versus The National Academy of Sciences 20 Top-Rated Universities and National Norms, 1975/76, 1980 and 1983

Year of Graduation	The 48 Liberal Arts Colleges		NAS 20 Top-Rated Research Universities		Nation	
	N	% of Tot.	N	% of Tot.	N	% of Tot.
1975/76 *	4,450	23.7%	8,113	15.9%	87,442	9.4%
1980	4,971	23.8%	6,973	14.1%	74,600	8.0%
1983	5,150	23.7%	N/A	N/A	70,000	7.5%
% Change, 75/76 to 80 :	11.7%	.7%	-14.1%	-11.1%	-14.7%	-14.5%
% Change, 75/76 to 83 :	15.7%	.0	N/A	N/A	-19.9%	-20.2%

Notes :

1. The percentage of all baccalaureate degrees from the 48 liberal arts colleges awarded to students having majored in the basic sciences has been a consistent 24% for nearly the past decade.
2. This is contrasted with the 16% proportional production of scientists among baccalaureates granted by the the top-rated universities in 1976, which fell to 14% by 1980.
3. Nationally, the proportional production of science undergraduates is under 10% and has declined significantly since the mid-1970's.
4. In absolute numbers of science baccalaureates conferred, both the nation and the top-rated university group decreased 14% to 15% between the mid-1970's and 1980. During the same period, however, the 48 colleges group numbers grew 12%, a growth that has continued to date.

Sources : The 48 colleges : internal survey. (see Table X for details)
University group : National Center for Education Statistics (unpublished data)
Nation : The Fact Book on Higher Education, 1984-85
(see Table V.A. for details; 1983 data estimated.)

* Data for the 48 colleges and the Nation are for 1975 baccalaureates.
Data for the university group are for 1976.

X. Aggregate Baccalaureate Degree Production :
The 48 Liberal Arts Colleges,
Absolute and Proportional Production by Discipline,
and % Change, 1975 to 1983

Undergraduate Major	1975		1980		1983		% Change 75 to 83	
	N	%	N	%	N	%	N	%
Biology	1,934	10.3%	1,882	9.0%	1,677	7.7%	-13.3%	-25.1%
Chemistry	690	3.7%	827	4.0%	786	3.6%	13.4%	-2.0%
Geology	254	1.4%	272	1.3%	366	1.7%	43.9%	24.3%
Mathematics	603	3.2%	736	3.5%	860	3.9%	42.6%	23.2%
Physics	229	1.2%	291	1.4%	394	1.8%	72.2%	48.8%
Other Sciences	737	3.9%	963	4.6%	1,067	4.9%	44.8%	25.1%
Sci. Sub-total	4,450	23.7%	4,971	23.8%	5,150	23.7%	15.7%	.0
Non-sciences	14,352	76.3%	15,892	76.2%	16,616	76.3%	15.8%	.0
Grand Total	18,802	100.0%	20,863	100.0%	21,767	100.0%	15.8%	.0

XI. Per capita Production of Ph.D.'s among All Baccalaureates :
The 48 Liberal Arts Colleges compared to
The Ivy League, the National Academy of Sciences
20 Top-Rated Universities, and the Big 10 Universities

Institutional Group	Number of Baccalaureates*	Number of PhD's**	Doctoral Productivity Ratio*** Per Capita
The 48 Liberal Arts Colleges	14,372	35,424	8.22%
The Ivy League Universities	11,841	27,846	7.84%
The NAS Top-Rated 20 Univ	41,186	85,486	6.92%
The Big 10 Universities	34,973	44,776	4.27%

Notes : The proportion of all recent baccalaureates graduated from the 48 liberal arts colleges going on the earn the Ph.D. exceeds that of three sets of major universities.

Definitions:

* Mean aggregate number of baccalaureate degrees conferred (all fields) per year, 1946 to 1976

** Total numbers of doctoral degrees granted between 1951 and 1980 (30 Yrs.) to individuals having earned undergraduate degrees from the various institutional groups

*** Ratio of mean annual Ph.D. production over the period to mean annual total baccalaureate production (expressed in percentage terms)

Sources : Fuller, Carol H., Analysis of Leading Undergraduate Sources of Ph.D.'s Adjusted for Institutional Size, The Great Lakes Colleges Association (GLCA), Ann Arbor, Mich., 1985.

XII. Share of the U.S. Total Undergraduate Science Market Enrolled at the 48 Liberal Arts Colleges versus that Enrolled at Private Universities of High Selectivity, 1976 to 1984

The 48 Liberal Arts Colleges :	1976			1984			
Intended Major	National Freshman Enrollment	48 Colleges Freshman Enrollment	48 College Share*	National Freshman Enrollment	48 Colleges Freshman Enrollment	48 College Share*	% Change In Share 76 to 84
Biological Sci.	110,476	3,001	27.16	65,152	2,460	37.76	39.0%
Chemistry	21,463	943	43.94	13,037	658	50.47	14.9%
Geology	4,802	100	20.83	2,784	50	17.96	-13.8%
Mathematics	17,819	939	52.70	13,871	886	63.87	21.2%
Physics	10,161	432	42.52	7,848	398	50.71	19.3%
Sci. Sub-total	164,720	5,415	32.87	102,692	4,452	43.35	31.9%

Private Universities, High Selectivity :	University's Freshman Enrollment	Univ. Share	University's Freshman Enrollment	Univ. Share*	% Change In Share 76 to 84
Biological Sci.	4,023	36.42	2,931	44.99	23.5%
Chemistry	920	42.85	598	45.87	7.1%
Geology	72	15.06	47	16.88	12.1%
Mathematics	701	39.33	628	45.27	15.1%
Physics	374	86.04	856	109.07	26.8%
Sci. Sub-total	6,590	40.01	5,060	49.27	23.2%

Notes :
1. The proportion (share) of all freshmen intending majors in the basic sciences enrolled at the 48 liberal arts colleges is nearly equal to that enrolled at all highly selective private universities.
2. Since 1976, the 48 colleges' share has grown 32% while that of the universities grew 23%.

Sources : The 48 Colleges: internal survey (see Table VII for details)
University group and nation: The American Freshman: National Norms, 1976 and 1984.

* Market share expressed in units of students enrolled per 1,000 availavble

XIII. U.S. Production of Baccalaureates in the Basic Sciences :
Share of the U.S. Total Science Baccalaureates Graduated from
The 48 Liberal Arts Colleges versus
The Share Graduated from the NAS 20 Top-Rated Universities,
1975 to 1980

The 48 Liberal Arts Colleges :

Science Discipline	1975 National Baccalaureate Production	1975 48 Colleges Baccalaureate Production	1975 48 College Share*	1980 National Baccalaureate Production	1980 48 Colleges Baccalaureate Production	1980 48 College Share*	% Change, 75 to 80, 48 Liberal Arts Colleges: N of Sci Grads	% Change, 75 to 80, 48 Liberal Arts Colleges: Share of Sci Grads
Bio. Scis.	50,172	1,934	38.55	42,670	1,882	44.10	-2.7%	14.4%
Chemistry	10,649	693	65.09	11,232	827	73.66	19.3%	13.2%
Geology	4,559	254	55.74	5,924	272	45.99	7.2%	-17.5%
Math.	18,346	603	32.86	11,378	736	64.64	22.0%	96.7%
Physics	3,716	229	61.55	3,396	291	85.64	27.2%	39.1%
Sci. Sub-tot	87,442	3,713	42.46	74,600	4,008	53.73	7.9%	26.5%

NAS Top-Rated 20 Universities :

	1976 University Baccalaureate Production	1976 Univ. Share*	1980 University Baccalaureate Production	1980 Univ. Share*	% Change, 76 to 80, 20 Top-Rated Universities: N of Sci Grads	% Change, 76 to 80, 20 Top-Rated Universities: Share of Sci Grads
Biological Sciences	5,205	99.54	4,329	101.45	-16.8%	1.9%
Physical Sciences	1,678	87.13	1,715	83.45	2.2%	-4.2%
Mathematics	1,230	76.47	929	81.65	-24.5%	6.8%
Sci. Sub-total :	8,114	92.59	6,974	93.49	-14.0%	1.0%

Notes : 1. The absolute number of baccalaureate degrees conferred in the basic sciences by the 48 liberal arts colleges grew 8% from 1975 to 1980.

2. This is equivalent to a 27% growth in the share of all U.S. baccalaureate degrees in the sciences awarded by these colleges.

3. During the same period, this share for the university reference group grew only one percent, and absolute numbers fell 14%

Sources : The 48 Colleges: internal survey (see Table X for details)
NAS 20 Top-Rated Universities: National Center for Education Statistics (unpublished data)
Nation: Fact Book on Higher Education, 1984-85 (see Table V.A. for details)

* Shares expressed in units of degrees awarded per 1,000 conferred nationally

XIV. A. Freshman Women's Interest in the Basic Sciences, 1976 and 1979
The 48 Liberal Arts Colleges
By Disciplines
(Freshmen Enrollments, WOMEN ONLY, all Institutions)

Prospective Major	1976 N	1976 %	1979 N	1979 %	% Change 76 to 79 N	% Change 76 to 79 %
Biology	1,383	11.6%	1,307	10.2%	-5.5%	-12.2%
Chemistry	311	2.6%	309	2.4%	-.7%	-7.9%
Geology	50	.4%	53	.4%	4.5%	-3.0%
Mathematics	347	2.9%	400	3.1%	15.1%	6.9%
Physics	69	.6%	96	.7%	40.0%	29.9%
Other Sciences	741	6.2%	978	7.6%	32.1%	22.6%
Sci. Sub-total	2,901	24.3%	3,143	24.4%	8.4%	.6%
Non-sciences	7,611	63.8%	7,822	60.8%	2.8%	-4.6%
Undecided	1,424	11.9%	1,895	14.7%	33.1%	23.5%
Freshman Total :	11,936	100.0%	12,859	100.0%	7.7%	.0

XIV. B. Proportional Representation of Women
By Prospective Major of Freshmen,
1976 to 1979

Prospective Major	% Women 1976	% Women 1979	% Change 76 to 79
Biology	46.1%	51.8%	12.5%
Chemistry	33.0%	40.0%	21.3%
Geology	50.2%	32.3%	-35.7%
Mathematics	37.0%	42.9%	15.9%
Physics	15.9%	18.3%	15.5%
Other Sciences	46.7%	52.4%	12.3%
Sci. Sub-total	41.4%	46.4%	11.9%
Non-sciences	63.1%	63.1%	.0
Undecided	47.8%	51.0%	6.7%
Freshman Total :	54.2%	56.2%	3.7%

Notes: 1. Approximately one-quarter (24%) of all freshmen women at the 48 liberal arts colleges intend to major in basic science.

2. The percentage of all prospective science majors made up by women has grown significantly in every discipline (except geology). By 1979, women had come to comprise nearly one-half of all prospective science majors.

Source : 48 colleges internal survey.

XV. A. Aggregate Baccalaureate Degree Production :
The 48 Liberal Arts Colleges,
Absolute and Proportional Production by Discipline
Women Only, all Institutions

Undergraduate Major	1975 N	1975 %	1980 N	1980 %	1983 N	1983 %	% Change 75 to 83 N	% Change 75 to 83 %
Biology	929	8.6%	1,036	8.3%	996	7.3%	7.3%	-15.0%
Chemistry	217	2.0%	286	2.3%	308	2.3%	42.0%	12.5%
Geology	101	.9%	104	.8%	132	1.0%	31.1%	3.9%
Mathematics	295	2.7%	358	2.9%	413	3.0%	40.4%	11.2%
Physics	33	.3%	41	.3%	91	.7%	175.0%	117.8%
Other Sciences	472	4.4%	596	4.8%	758	5.6%	60.7%	27.3%
Sci. Sub-total	2,046	19.0%	2,422	19.5%	2,700	19.9%	32.0%	4.5%
Non-sciences	8,705	81.0%	10,017	80.5%	10,873	80.1%	24.9%	-1.1%
Grand Total	10,750	100.0%	12,439	100.0%	13,572	100.0%	26.3%	.0

XV. B. Proportional Representation of Women Among Graduates
The 48 Liberal Arts Colleges
Science and Non-Science Disciplines
1975, 1980 and 1983

Undergraduate Major	% Women 1975	% Women 1980	% Women 1983	% Change 75 to 83
Biology	48.0%	55.1%	59.4%	23.7%
Chemistry	31.3%	34.6%	39.2%	25.2%
Geology	39.7%	38.3%	36.2%	-8.9%
Mathematics	48.9%	48.6%	48.1%	-1.5%
Physics	14.5%	14.2%	23.1%	59.7%
Other Sciences	64.0%	61.9%	71.0%	11.0%
Sci. Sub-total	46.0%	48.7%	52.4%	14.0%
Non-sciences	60.7%	63.0%	65.4%	7.9%
Grand Total	57.2%	59.6%	62.4%	9.1%

Notes:
1. Approximately one-fifth of all women graduates of the 48 liberal arts colleges earn majors in basic sciences.
2. The percentage of all science graduates made up by women has grown significantly in every discipline (except geology and mathematics). Since 1975, the percentage of all science graduates made up by women has grown from 46% to more than half.

Source : 48 colleges internal survey.

Chapter II

The Undergraduate Education of Scientists at the Liberal Arts Colleges

"The value of my undergraduate program was the individual attention that the professors were able to provide. The emphasis of the professors is on teaching, not research, and hence they are able to spend more time with the students. Every class was given by a Ph.D. "teacher-scholar", never by a graduate student. The individual attention and support I received, coupled with the freedom to independently pursue research problems, allowed me to publish research results in professional journals while still an undergraduate."

--- Richard P. Binzel, Department of Astronomy, University of Texas (Macalester)

The data presented in Chapter I demonstrate unequivocally the eminence of the 48 liberal arts colleges with respect to their national role in the undergraduate training of scientists in America.

* Their proportion of freshmen intending to major in the basic sciences has long been, and remains, far above both national and peer group averages. Most importantly, this percentage is nearly double the aggregate proportional interest in the sciences at all highly selective private universities.

* The percentage of graduates from the liberal arts colleges earning degrees in the sciences is very high, far higher than for the nation and, again, higher than at the top-ranked public and private universities.

* These proportions for the liberal arts colleges have been, at worst, only slightly affected by the severely negative national and university trends of the past ten to fifteen years.

* As a result, these colleges have been enrolling and educating a significantly increasing proportion of all American scientists in recent years. Their share of the prospective freshman science market grew 32% from the mid-1970's to 1984. Their share of all baccalaureates awarded in the basic sciences grew 27% from 1975 to 1980.

* These colleges are unsurpassed in their per capita production of alumni in the sciences who go on to earn doctorates.

These facts are not the results of chance. Certain systematic conditions exist, unique to the liberal arts colleges and carefully preserved by them, which attract a disproportionate and growing share of the high-ability college-bound science market, provide them with highest-quality education in science and research, and inspire them to go on to scientific careers.

This chapter will present the data generally relevant to the educational process at the 48 liberal arts colleges. Particular attention is paid to identifying those aspects essential to high-quality education in the sciences. Many of these characteristics will be familiar. Nevertheless, it is important to document current conditions and trends, contrasting them to national standards, particularly those of research universities. It is these institutional strengths which must be preserved zealously and vigorously improved if these institutions are to maintain their vital role in the preparation of America's scientists. On many of these measures too, the 48 liberal arts colleges significantly out-perform research university reference groups.

The Science Faculty: The First and Strongest Attribute

Foremost in the successful education of scientists is the science faculty. It is they who must pass on the broad concepts and voluminous specific knowledge of their disciplines, provide the training in basic research methodologies, impart a life-long devotion to their fields, and instill commitment to the progress of scientific inquiry generally. The key facts about the science faculties at the 48 liberal arts colleges are:

* Fully one-quarter of the total teaching strength of these colleges is devoted to the basic sciences (Table I).

* This proportion varies within the conference group from eight institutions devoting slightly below 20% to seven institutions devoting more than 30%, and one with fully half of the teaching FTE dedicated to the sciences.

* Biology, mathematics and chemistry have the largest faculties, each comprising slightly more than 5% of the teaching strength of these colleges. Physics and "other sciences" each average approximately 3%, and geology commands the smallest portion, 1.9% (several of these institutions do not offer a major in this discipline).

* Slightly more than half, 56%, of the teaching strength in the sciences is represented by faculty members holding continuous tenure. One-quarter (26%) is in tenure-track positions but not tenured. Thus 82% of the science faculty at these institutions hold continuing positions. Of these, two-thirds are currently tenured.

* The remaining teaching strength (18%) is evenly divided between faculty replacing continuing members on leave and by other temporary appointments (typically supported by external funds).

* The tenure ratio in the standard sciences is equal to that of all non-science faculty and is close to the tenure ratio at major American universities (NSF 81-323).

* The tenure ratio varies insignificantly by discipline, except for the "other science" faculty (e.g., computer science, astronomy, etc.) Here, a lower than average percentage (46%) of positions are held by tenured faculty members and a higher proportion by tenure-track faculty (31%) and temporary appointments (17%). This most likely results from the relatively recent introduction at these colleges of many of the disciplines subsumed under the "other" category.

Research and Scholarly Activity: The Next Essential Ingredient

To keep science curricula and faculty members at the cutting edge of their disciplines, and to be able to teach the research skills essential to scientific inquiry, faculty members themselves must be professionally active in their fields. In addition to the basic demographic statistics above, it is clear that the science faculties of the 48 liberal arts colleges are very active in current, on-going research and scholarship:

* Nearly 60% have published one or more articles in professional journals during the past five years (Table II. A). In this period, 1,428 faculty of the 48 liberal arts colleges published 6,961 journal articles. They produced an average of approximately five articles per person over this period, or one article per person per year.

* This productivity rate coupled with the proportion of faculty actively publishing yields an average 0.6 journal articles per all science faculty members per year. This compares favorably with a mean 0.5 per person per year found among 20 top-ranked, private, undergraduate colleges in a study published in 1981 (Spencer and Yoder).

* Half of all science faculty members at these colleges have recently presented papers at professional conferences: 1,140 science faculty at these institutions gave 4,478 such presentations, nearly four per every professor over the period (Table II. B).

* In the past five years, these faculty members have also published a total of 351 books and 3,549 reviews (Table II, C and D).

* These data vary by discipline.

Faculty-Student Interaction and Student Research Opportunities: The Liberal Arts Colleges' Unique Offering

A competent and active faculty alone, however, does not assure high-quality science education. Frequent, close contact between students and faculty is essential to success in the educational process. No amount of research and scholarly activity will benefit the undergraduate if this vital interaction does not take place in significant quantity. Such contact with distinguished faculty is perhaps the primary hallmark of undergraduate science education at the 48 liberal arts colleges.

The development of true command of scientific disciplines requires substantial hands-on experience in the laboratory; a great deal of careful training in research methodology; and the interactive give and take with professors and peers in which working knowledge of the field and specific interest areas is developed, challenged and absorbed. These liberal arts colleges and their exceptional, active science faculties create an unsurpassed environment for providing science students abundant, close interaction with mentors, extensive research experience at the undergraduate level, and the opportunity to publish research findings:

* Between one-third (biology, chemistry and geology) and more than one-half (mathematics) of all science courses at the 48 liberal arts colleges are offered at the introductory level and, thus, are available to meet the high freshman demand for science instruction (Table III). These institutions need not practice a "weed them out early" policy nor offer only very large introductory science courses in order to handle student loads.

* Nearly half of all introductory science courses at these colleges are taught by tenured, proven members of the science faculty. Thus most of the instruction provided to first-year

science students by these colleges is performed by the primary, relatively permanent and most accomplished faculty members. Between 70% and 85% are taught by faculty in tenured and tenure-track positions.

* Tenured and tenure-track faculty are thus dedicated to introductory science in close proportion to their representation on the faculties.

* These conditions, all very conducive to highest-quality science education at the undergraduate level, are typically not found at major research universities. Among all universities, a 1981 National Science Foundation study (NSF 81-323) found that such university faculty members spend one-third of their time in research and less, 29.6%, in all instructional activities, time which includes the substantial teaching of graduate students. In contrast, the faculty at all four-year colleges devote nearly twice this proportion, 54.9%, to teaching, essentially all of which is for undergraduates.

* An average of 15.9 science students per institution per summer, a total of 761 in the summer of 1983, were actively engaged as research assistants in on-going faculty research projects (Table IV).

* During the academic year, far more students yet participate in these invaluable research experiences: 45.5 per institution per year, a total of 2,183 in 1983-84 alone.

* Honors research projects, primarily carried out by senior majors, were similarly plentiful at these 48 liberal arts colleges: an average of 21.5 per institution per year, a total of 1,031 in 1983-84.

* An even greater 36.3 students per college per year engaged in other independent research projects totaling nearly 1,750 such projects, and students conducting them, in 1983-84.

* Of the 6,961 journal articles emerging from these 48 liberal arts colleges in the past five years, 1,899, or nearly one in three, were co-authored by students (Table II. A). Twenty-seven were solely authored by students.

* The proportion for student co-authorship of papers presented at professional conferences is nearly one in every five for the 48 liberal arts colleges (Table II. B).

* Students co-authored eight of the books recently published by faculty members of these institutions and five percent of all literature reviews (Tables II, C and D).

* Comparable data for universities are sparse. Nevertheless, an article on undergraduate research published in Chemical and Engineering News (October 4, 1982) reported that "Robert West, professor of chemistry at the University of

Wisconsin, Madison, noted that about 40 undergraduates per year (less than 1%) carry out research in chemistry . . . " He also indicated that "in the past 10 years, about 4% to 5% of the chemistry papers published by UW scientists have been co-authored by undergraduates." While this is only a single institution and discipline, it would be unlikely that more than double these percentages would obtain for undergraduate science students generally at major research universities. As was also noted in the article, "A major disadvantage, West says, is that undergraduates require a lot of supervision and training; the return on the time and money invested in them often is seen as not worthwhile."

These data coalesce into a coherent picture of the preparation of scientists by the 48 liberal arts colleges. Exceptionally high freshman demand of the highest aptitude is met in plentiful introductory courses taught by distinguished science faculty, active in research and publication in their fields, and dedicated to teaching at the undergraduate level, particularly of first-year students. As initial interest is nurtured and competence developed, undergraduate students engage in a large number of research projects, both as assistants to their mentors and, later, on an independent basis. Very often, these experiences lead to co-authorship with faculty members of articles in the professional journals and of conference papers. The result is large numbers, and an unusually high percentage, of baccalaureates earning degrees in the sciences, a uniquely high proportion of whom subsequently earn doctorates in their fields and pursue careers in science.

Investing in the Future of American Science

Investments in the immediate and long-term future of both basic and applied science in America could not be wiser than those made in these 48 liberal arts colleges. It is not likely that a more productive, higher real return per dollar expended could be found. Such monies:

* reach very bright, highly motivated science students in the greatest proportion per capita;

* fund science research and education at a set of institutions whose role in undergraduate science in America is expanding and likely will continue to do so;

* support the work of exceptional, active teacher-scholars in the sciences;

* provide assistance to science students who go on to graduate education and careers in the sciences in unsurpassed proportion.

Issues for the Future of Undergraduate Science Education

The liberal arts colleges have long been the most productive undergraduate training ground for America's scientists. However, if they are to continue to provide their vital contribution to the nation's scientific resources, substantial new investments will be essential.

* Given heavy teaching loads, particularly of freshman and sophomore students, all of which is carried by faculty members themselves, and given limited resources to afford more than a few replacement faculty to allow regular professors time away from teaching, relatively little time remains for faculty at the liberal arts colleges to pursue significant on-going research.

* The NSF science faculty's activity study (NSF 81-323) found that among all four-year colleges only 10% of faculty time could be devoted to research, "reflecting in part the low level of federal support at this level. About three-fifths of 4-year college research hours were unsponsored, as compared to only one-fourth in universities."

* While 30% of the freshman choosing these 48 liberal arts colleges enroll intending to major in the sciences, only 25% actually do so. There is a net out-flow from the sciences, even accounting for student attrition. The equivalence between the percent dedication of total FTE teaching strength to the sciences (25%) and the percentage of graduates earning science majors is not accidental. Science faculty can be expected to assume only a fair share of institutional student load. Given the high freshman demand for science at these colleges and their great success in educating those who do major in the sciences, it appears that an increase in the absolute teaching strength dedicated to the sciences at these institutions likely will result in the output of greater numbers of highly-educated, talented science graduates who subsequently will go on to doctorates and careers in science, thus increasing the numbers and enriching the quality of the American scientific community.

* If more faculty members are to be active in current, meaningful research, and if students are to be trained in modern methods of scientific inquiry, then more and better laboratories, equipped with state of the art instrumentation, must be made available. This means both additional physical facilities on these campuses, and the acquisition, operation and maintenance of new scientific and computing equipment. Such costs are substantial, beyond the reach of the internal resources of these institutions.

All these needs can be met only with substantial monetary investment. There is ample evidence that such investments will yield bountiful, positive improvements for science in America. However, no such significant capital in-flow is imminent. Indeed, there is evidence that these colleges actually have lost ground nationally in the funding for science on most, if not all, measures. For the sake of the nation's scientific and economic future in a rapidly increasingly technological world, such conditions must not be permitted to continue.

The next chapters explore the national and institutional funding of basic science and offer specific recommendations for preserving the vitality of science at these 48 liberal arts colleges as an essential ingredient in the nation's scientific strength.

Sources - Chapter II

1. Activities of Science and Engineering Faculty in Universities and 4-Year Colleges; 1978/79, National Science Foundation,- NSF 81-323, Tables A-11 (p.19), B-27 (p.35), B-38 (p.40), B-41 through B-46 (pp.42-44), B-53 through B-58 (pp.48-53).

2. Chemical and Engineering News, "Undergraduate Researchs Gets High Marks", pp.36-37, Oct. 4, 1982.

3. Spencer J., and Yoder C., A Survey of Undergraduate Research over the Past Decade, Journal of Chemical Education, Vol. 58, pp.780-786, 1981.

I. Aggregate Full-Time Equivalent (FTE) Teaching Strength Devoted to the Sciences, and Tenure Ratios by Discipline, The 48 Liberal Arts Colleges, 1983-84.

Discipline		Tenured	Tenure Track	Replacement	Temporary and Other	Total Teaching Strength	% of Total
Biology	FTE	256.7	99.5	43.4	21.6	421.1	5.7%
	%	61.0%	23.6%	10.3%	5.1%		
Chemistry	FTE	211.8	89.8	33.1	27.6	362.4	4.9%
	%	58.5%	24.8%	9.1%	7.6%		
Geology	FTE	78.8	38.3	12.3	8.9	138.3	1.9%
	%	57.0%	27.7%	8.9%	6.4%		
Mathematics	FTE	211.2	119.1	42.5	44.8	417.6	5.6%
	%	50.6%	28.5%	10.2%	10.7%		
Physics	FTE	153.6	53.6	24.5	18.5	250.3	3.4%
	%	61.4%	21.4%	9.8%	7.4%		
Other Sciences	FTE	108.5	74.7	14.7	40.5	238.4	3.2%
	%	45.5%	31.3%	6.2%	17.0%		
Science Sub-Total	FTE	1,020.7	475.0	170.5	161.9	1,828.1	24.5%
	%	55.8%	26.0%	9.3%	8.9%		
Science Faculty as % of Total FTE :		24.8%	23.7%	25.3%	24.2%		
Non-Science	FTE	3,087.9	1,527.5	502.5	506.3	5,624.3	75.5%
	%	54.9%	27.2%	8.9%	9.0%		
Grand Total :	N	4,108.6	2,002.6	673.0	668.2	7,452.3	100.0%
	%	55.1%	26.9%	9.0%	9.0%		

Notes :

1. Approximately one-quarter (24.5%) of the aggregate full-time equivalent (FTE) teaching strength of the 48 liberal arts colleges is devoted to the sciences.

2. The percentages of the FTE teaching strength which are tenured and on tenure-track in the sciences are nearly equal to those in the non-sciences. They vary insignificantly by individual science discipline, except for the "other sciences" category and, to a lesser extent, mathematics.

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II. Scholarly Activity of the Science Faculty by Discipline :
Journal Articles and Conference Papers,
The 48 Liberal Arts Colleges,
1979-80 through 1983-84

A: Journal Articles

Discipline	Headcount Faculty*	N of Fac. Pblish.**	% Pblish.	Numbers of Journal Articles: Sole Author	Co-author w/ Faclty	Co-author w/ Studnt	Co-author w/ Stu & Fac	Total Articles	Articles per Fac.	% Student Co-Author
Biology	551	396	71.9%	555	901	494	193	2,144	5.41	32.1%
Chemistry	561	326	58.2%	229	658	539	202	1,628	4.99	45.5%
Geology	180	132	73.3%	268	265	55	25	613	4.64	13.1%
Mathematics	602	277	46.0%	569	325	32	5	931	3.36	4.0%
Physics	387	192	49.6%	335	487	112	73	1,007	5.24	18.4%
Other Sciences	184	104	56.7%	211	258	122	48	639	6.13	26.6%
Science Totals :	2,465	1,428	57.9%	2,167	2,894	1,353	546	6,961	4.87	27.3%

B: Conference Papers

Discipline	Headcount Faculty*	N of Fac. Pblish.**	% Pblish.	Numbers of Conference Papers: Sole Author	Co-author w/ Faclty	Co-author w/ Studnt	Co-author w/ Stu & Fac	Total Papers	Papers per Fac.	% Student Co-Author
Biology	551	347	63.0%	696	395	227	109	1,427	4.11	23.5%
Chemistry	561	202	36.0%	493	227	203	35	959	4.75	24.9%
Geology	180	126	69.8%	296	168	71	13	548	4.36	15.2%
Mathematics	602	225	37.4%	529	95	10	9	643	2.85	2.9%
Physics	387	155	40.2%	212	240	58	68	577	3.72	21.8%
Other Sciences	184	84	45.9%	209	70	26	19	324	3.84	13.9%
Science Totals :	2,465	1,140	46.2%	2,436	1,195	595	252	4,478	3.93	18.9%

* Headcount of persons having held teaching faculty status, 1979-80 through 1983-84
** Headcount of such faculty having published at least one item of the type examined

II. Scholarly Activity of the Science Faculty by Discipline :
Books and Literature Reviews Published,
The 48 Liberal Arts Colleges,
1979-80 through 1983-84

C: Books Published

Discipline	Headcount Faculty*	N of Fac. Pblish.**	% Pblish.	Numbers of Books Published: Sole Author	Co-author w/ Faclty	Co-author w/ Studnt	Co-author w/ Stu & Fac	Total Books	Books per Fac.	% Student Co-Author
Biology	551	43	7.7%	21	40	0	0	60	1.42	.0
Chemistry	561	38	6.8%	48	49	0	0	97	2.54	.0
Geology	180	32	17.5%	16	22	1	0	40	1.26	3.4%
Mathematics	602	48	8.0%	40	26	0	4	70	1.46	5.9%
Physics	387	19	5.0%	30	12	0	0	43	2.21	.0
Other Sciences	184	22	11.9%	25	14	3	0	41	1.88	6.7%
Science Totals :	2,465	202	8.2%	180	163	4	4	351	1.74	2.3%

D: Literature Reviews

Discipline	Headcount Faculty*	N of Fac. Pblish.**	% Pblish.	Numbers of Literature Reviews: Sole Author	Co-author w/ Faclty	Co-author w/ Studnt	Co-author w/ Stu & Fac	Total Reviews	Reviews per Fac.	% Student Co-Author
Biology	551	219	39.7%	555	75	32	20	681	3.11	7.5%
Chemistry	561	116	20.6%	455	32	20	12	518	4.48	6.1%
Geology	180	70	38.7%	246	37	15	3	302	4.33	6.2%
Mathematics	602	177	29.5%	1,056	19	1	3	1,079	6.08	.4%
Physics	387	117	30.3%	497	53	5	2	555	4.74	1.1%
Other Sciences	184	80	43.5%	328	29	54	3	414	5.18	13.9%
Science Totals :	2,465	779	31.6%	3,136	244	127	42	3,549	4.56	4.8%

* Headcount of persons having held teaching faculty status, 1979-80 through 1983-84
** Headcount of such faculty having published at least one item of the type examined

III. Analysis of Course Offerings in the Sciences
By Discipline, Level and Tenure Status of Professor
The 48 Liberal Arts Colleges, 1983-84

Discipline	Total Courses	Introductory Courses: Major	Introductory Courses: Non-Maj.	Intrmed. & Adv.	All Other	% Intro.
Biology	1,478	263	231	880	104	33.4%
Chemistry	1,236	291	128	682	135	33.9%
Geology	511	87	88	304	31	34.3%
Mathematics	1,947	560	534	788	65	56.2%
Physics	945	206	236	454	50	46.7%
Other Sciences	896	222	186	445	44	45.5%
Totals :	7,014	1,629	1,403	3,553	429	43.2%

Discipline	Total Intro. Courses	Intro. Tght. by Tenured	% Tght. by Tenured	Intro. Tght. by Tenured + Ten. Trck	% Tght. by Tenured + Ten. Trck
Biology	494	272	55.0%	404	81.8%
Chemistry	419	241	57.4%	351	83.7%
Geology	175	96	54.8%	154	88.1%
Mathematics	1,095	449	41.0%	753	68.8%
Physics	441	263	59.7%	351	79.7%
Other Sciences	407	131	32.1%	274	67.3%
Totals :	3,032	1,451	47.9%	2,287	75.5%

Notes :

1. Between one-third (biology, chemistry and geology) and over one-half (mathematics) of all course offerings in the basic sciences at the 48 liberal arts colleges are introductory courses. The aggregate mean for all disciplines is slightly over two-fifths (43.2%).

2. Of all introductory courses, nearly half (47.9%) are taught by tenured faculty. Three-quarters (75.5%) are taught by faculty either tenured or on tenure track. These percentages are nearly equal to the proportional representation of such faculty in the FTE teaching strength (see Table I).

IV. Various Opportunities for Undergraduate Student Research :
The 48 Liberal Arts Colleges,
1983-84

Discipline	Paid Student Assistants Summer '83	Paid Student Assistants AY 83-4	Students with Honors Projects	Other Indpdnt. Student Research	Non-Stdnt. Paid Research Associates
Biology	245	573	325	699	92
Chemistry	336	400	252	305	29
Geology	38	164	181	169	7
Mathematics	21	340	128	118	5
Physics	65	318	77	169	19
Other Sciences	56	388	68	280	25
Totals :	761	2,183	1,031	1,740	178
Means per Institution :	15.9	45.5	21.5	36.3	3.7

Chapter III

Research and Development in America and the Future of Undergraduate Science at the Liberal Arts Colleges

"If liberal arts colleges are to survive in the highly competitive arena of science, they will have to recruit and retain good scientists who are willing and eager to teach provided they are not only permitted but encouraged and supported in pursuing research that is appropriate and consistent with the science mission of the institution. This means, among other things, that the institutions will have to guarantee adequate financial support from its endowments or other sources if the science faculty is not able to garner the requested research grant suport from outside sources. The best scientific research comes from people who are broadly educated, preferably in a liberal arts college with a strong science program."

— Albert Balows, Asst. Dir. for Laboratory Science, Dept. of Health and Human Services (Colorado College)

Research and Development in America

* The total expenditures in the United States for all research and development (R&D) in 1984 were $97 billion.

* In recent years, total expenditures for R&D have been growing fairly rapidly. The fiscal year 1984 figure of $97 billion is up 11%, 6% real, over that of FY83. The growth rates from FY81 to FY82 and from FY82 to FY83 were both 5% real.

* In FY85, total R&D spending is projected to rise 7% real, to $110 billion. Increasingly, the growth in total R&D has come from governmental sources, almost exclusively increased federal funding for defense-related development.

* This $97 billion expended in FY84 for all R&D was 2.7% of that year's GNP. This percentage has been rising slowly but steadily since its nadir of 2.2% in FY78.

* The $97 billion is also almost exactly equal to the sum of all the educational and general budget expenditures by all U.S. institutions of higher education in 1984-85 (95.5 billion). That is, the R&D effort in America and American higher education are roughly equivalent in gross size.

* All research and development divides into approximately one-third research (34.3%) and two-thirds development (65.7%). Research further divides into basic research and applied research, again approximately in a 1:2 proportion. In the end, basic research in America is 12% of total R&D spending, or $11.85 billion in FY84 (Table I, Graph I. A).

Funding Science in America: Industry and Government

The funding of the national research and development effort and the performance of it form a complex web of inter-relations between the four major sectors involved in R&D: the national government, business and industry, academia and a set of all other private, non-profit institutions. On the supply side, the FY84 $97 billion was funded 51% by Industry, 46% by Government, 2% by Academia and 1% by other non-profit institutions (Table II, Graph II. A).

* Since 1960, industry has been supplying a steadily greater share of the total funds for American R&D. Since 1981, industry has surpassed government in R&D funding by an increasing margin, even though federal R&D expenditures have been growing.

* All the internal monies spent by colleges and universities for R&D amount to only 2% of total R&D expenditures, $2.1 billion in FY84.

Performing America's Research and Development: Industry and Academia

On the production side, however, research and development is performed by these four sectors in very different proportion than it is funded: 74% by Industry, 11% by Government, 12% by Academia and 3% by other non-profit institutions (Table III, Graph III. A).

* While the government supplies the resources for 46% of all R&D, it performs only 11% of it. The remaining is performed predominantly by industry and the nation's colleges and universities.

* Academia is the second largest performer of research and development in America, 12% of the total.

* Academia's gross R&D effort is funded very differently than is the national total: 73% by the federal government, 18% from internal sources, 5% by the other non-profit sector and, last, only 4% by business and industry (Table VIII, Graph II. B). What it performs is equally different.

Research and Development in the Academic Sector: Primarily Basic Research

The chief reason for this low level of funding by industry of research and development in the academic sector is that this sector is almost exclusively dedicated to research (88%), and not to the development (12%) with which industry is immediately concerned. Further, this 88% devotion of academic R&D to research is 60% in basic research and only 28% in applied research (Table IV, Graph I. B). Again, industry has long tended to be too little interested in unapplied research to see great advantage in its funding of basic research. Therefore, given the very limited uncommitted resources in the other non-profit sector and in academia itself, the government is the lone remaining source for the funding of basic research in America, research primarily carried out in the nation's colleges and universities:

* Of all basic research in America (12% of the R&D total, $11.9 B in FY84), the government funds two-thirds, $7.8 B in 1984. Industry pays for one-fifth, and others only 5%. The academic sector funds 10% of the nation's basic research from its own resources, $1.2 B in FY84 (see Table V).

* However, of all basic research, the academic sector[1] alone performs nearly 60%, $6.8 B in FY84 (Table VI, Graph III. B). The remaining portion, 42%, is performed by industry (19%), government (15%), and the other non-profit sector (8%).

* Of the government's two-thirds support of all basic research, fully 65% ($5.00 B in FY84) goes into the academic sector.

* These federal monies in turn form nearly three-quarters (73%) of all expenditures by colleges and universities for basic research (Table VII), and nearly three-quarters (73%) of all academic R&D (Table VIII, Graph II. B).

Therefore, the United States is heavily reliant on the academic sector, its colleges and universities, for the nation's basic research, and this sector in turn is heavily reliant on the federal government for support of these vital activities.

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[1] Including the 19 federally-financed research and development centers (FFRDC) administered, but not funded, by academic institutions. For examples, Lawrence-Livermore, Los Alamos, JPL, Argonne, Brookhaven, SLAC, etc. FFRDC's perform approximately 15% of all basic research done in the academic sector.

Basic Research in America: Going Up

Given academia's dedication primarily to basic research, the conditions and trends within this area are of most importance to colleges and universities. As a percentage of total R&D spending, basic research has been a diminishing portion (Table I): 13.6% in 1970, 13.1% in 1975, 12.9% in 1980 and 12.2% in 1984, primarily due recently to much greater federal funds flowing into development (for defense). However, within basic research itself, the trends are positive:

* Expenditures for basic research rose 3% in real terms from FY82 to FY83. From FY83 to FY84, they grew 7% in constant dollars.

* Since 1975, expenditures for basic research have grown 41% in real terms. The federal portion of these funds (65-70%) grew 35% in constant dollars, while industrial spending grew 79% real over this period (Table V). That is, in spite of industry's low level of support for basic research, it is increasing this commitment in real terms at a rapid pace.

* Industrial support for basic research conducted by the academic sector is also rising rapidly, particularly in recent years. From FY82 to FY83, it grew from $190 M to $225 M, or about 12% in constant dollars. In FY84, it increased to $260 M, approximately 10% real growth. From FY84 to FY85, it is projected to grow 16% in current dollars, 11% in constant dollars. This is a cumulative real growth of approximately 37% from FY82 to FY85.

* As a result, the portion of college and university basic research which is industrially supported has risen steadily, doubling since 1970 from 1.9% to 3.8% in 1984. As recently as 1980, it was only 2.8% (Table VII).

* College and university spending from internal funds for basic research rose 5% in real terms from FY82 to FY83, and 9% real from FY83 to FY84.

* Although a greater share of all federal R&D funding has been going for development, primarily defense-related, the non-defense federal R&D monies have been significantly more dedicated to basic research. Since 1980, non-defense federal spending for development has fallen from 42% to 27%, while the share of this spending devoted to basic research has risen from 27% to 38% (Keyworth).

The Liberal Arts Colleges and the Funding of Science in America

For all these positive conditions and trends, there is little encouraging for the general baccalaureate institutions. Nearly all of the monies for research and development in the United States, even those for basic research, flow into the major public and private research universities. The 100 academic institutions receiving the largest dollar amounts of all federal aid to education[2], not surprisingly, are all doctorate-granting universities. In FY82, these top 100, roughly three percent of all U.S. colleges and universities, received 61% of all federal aid to education. However, their share of federal support to the academic sector for science was even greater. They received (Table IX):

* 83% of all federal funds to colleges and universities for all science and engineering activities;
* 84% of all federal R&D monies awarded to educational institutions;
* 86% of all National Science Foundation obligations to academia in FY82;
* 91% of all federal funds for facilities and instrumentation for science instruction.

All 353 doctorate-granting institutions in FY82 received 76% of all federal support to education. With respect to funding for science, however, they received (Table IX):

* 97% of all federal money to academia for science and engineering;
* 98% of all federal R&D support to the academic sector;
* 99% of all NSF funds going to the academic sector;
* 100.0% of federal funds for facilities and instrumentation for science instruction.

All general baccalaureate institutions, on the other hand, recently have been receiving a greater share of the total federal support for education. From FY81 to FY82, for example, the portion of these monies for such schools rose from 6.0% to 7.3%. However, their share of federal monies for science has diminished dramatically. Between these same two fiscal years, for example, the proportion of total NSF support to the academic sector received by all general baccalaureate institutions fell from 2.2% to 1.3%. This was a -41%

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[2] including, for example, all student financial aid

loss in nominal dollars, from $15.7 million to $9.2 million in a single year.

The 48 selective colleges of the liberal arts and sciences, represented at this conference for their outstanding role in undergraduate science from 1978 to 1982 (Table IX):

* have seen total federal support rise only $2.9 million nominal dollars, from $44.6 M to $47.5 M, a 28% decline adjusted for inflation (by CPI).

* This translates into a decrease in the proportion of all federal dollars for education over five years from 0.60% to 0.55%.

* Over this period, these 48 colleges' share of all federal support to the academic sector for all science and engineering activity fell from 0.27% ($10.8 M) to 0.20% ($10.7 M), a 33% decline in real terms.

* The proportion of federal R&D support to the 48 liberal arts colleges also declined over these five years, from 0.23% ($7.7 M) to 0.21% ($9.5 M), a 16% reduction in constant dollars.

* The NSF funding received by the 48 liberal arts colleges over this period fell precipitously. By FY82, these schools, vital to undergraduate science in America, received only one-third of their FY78 NSF support in real terms. In FY78, these 48 colleges received $5.3 million, 0.87% of all NSF support to the academic sector that year. In FY82, their total was only $2.8 M, 0.38% of all NSF funds for colleges and universities, a nominal dollar decline of 48% in five years. In constant 1978 dollars, the FY82 NSF support to these 48 liberal arts colleges was $1.9 M, for a -65% real dollar loss over the period.

* In FY78, 19 of the 48 colleges received a total of $228,000 for facilities and instrumentation for science instruction. By FY82, these funds had gone to zero for all of these schools. Between these two years, total government support for this purpose fell from $22.7 million to $0.8 million.

In short, recent federal policy has reduced drastically the support for the sciences, and particularly for science instruction, at the very institutions which have been the undergraduate training ground for significant numbers of America's most promising scientists and engineers, and traditionally have been among the primary feeder schools for the nation's best graduate-level science programs. Equally important, it has done so at a time when freshman intention to major in the sciences is waning, undergraduate and graduate enrollments are declining absolutely and will continue to shrink for a

decade or longer, and the production of both baccalaureates and doctorates in most science fields is diminishing.

These trends come at a difficult point in the history of world society and of education generally, including the 48 liberal arts colleges, given the explosive recent growth in science and technology. It is absolutely essential to society and to the U.S. economy at this time at least to maintain present levels of scientific training and production of high-ability scientists, as well as to provide a more thorough general technological literacy in the general population. These are precisely the tasks at which the 48 conference colleges excell. However, to continue to do so will become increasingly expensive and certainly cannot be accomplished with crippling reductions in funding such as those just detailed.

The Costs of Undergraduate Science

The 48 conference colleges were asked to provide estimates from their long-range planning models of the monetary resources necessary to maintain their present program in the sciences, and to keep current with new technologies. Although these data varied by institution, the averages per institution are presented in Table X (following page).

Equipment, particularly the need for state-of-the-art computing in a rapidly evolving technology, leads these growth rates, followed by the capital costs of more and modern laboratory space.

* Spending required for all equipment-related costs will rise by the end of the present decade to levels nearly half again as large as in 1983-84 in real terms. Nominally, they will essentially double.

* For computing technologies, costs will grow fully 50% in real terms by 1990.

* Capital expenditures for science will rise 23% real, and 63% nominally, to over three million dollars per institution per annum.

* Science personnel costs, primarily for faculty, will require similar growth rates, from the average $1.6 million to $1.9 million per college per year in 1984 dollars, up 21% real, or 61% nominal growth to $2.5 million annually.

These amounts are beyond the unaided capacity of these institutions to fund them. Sources of significant incremental support for science education and research at these schools must become available if the science programs at these colleges are to be maintained. If these programs are not maintained, a vitally important base of science and engineering personnel will be eroded. Even if the erosion were

X. Current and Projected Expenditures for Science, 1984 to 1990
The 48 Liberal Arts Colleges

Means per Institution ($ in Thousands)

Personnel	Expenditures per College 1983-84 ($ Th)	Mean Annual % Real Growth	Mean Annual % Nominal** Growth	Projected Fiscal Needs for Science (In Thousands of Current Dollars) 1985-86	1987-88	1989-90
Faculty	$1,305.8	3.4%	8.4%	$1,534.4	$1,803.0	$2,118.6
Staff	$160.1	2.8%	7.8%	$186.1	$216.3	$251.3
Internal Support	$24.0	2.1%	7.1%	$27.6	$31.6	$36.3
Tech. Support	$49.3	1.9%	6.9%	$56.3	$64.3	$73.5
Reported Totals *	$1,585.6	3.2%	8.2%	$1,856.3	$2,173.2	$2,544.3
Persnl. as % of Total	41.1%					
			Nominal % Growth :	17.1%	37.1%	60.5%
Equipment						
Eqp. Purchase	$151.5	6.0%	11.0%	$186.6	$230.0	$283.3
Computing Support	$192.2	7.2%	12.2%	$241.9	$304.6	$383.4
Repair & Maint.	$39.2	5.8%	10.8%	$48.2	$59.1	$72.6
Reported Totals *	$382.9	6.6%	11.6%	$476.9	$594.0	$739.8
Eqpmnt. as % of Total	9.9%					
			Nominal % Growth :	24.5%	55.1%	93.2%
Capital Investment						
Buildings	$1,082.1	2.6%	7.6%	$1,252.8	$1,450.5	$1,679.4
Laboratories	$242.5	4.4%	9.4%	$290.2	$347.4	$415.7
Classrooms	$346.4	2.9%	7.9%	$403.3	$469.6	$546.7
Offices	$113.2	1.4%	6.4%	$128.1	$145.0	$164.2
Reported Totals *	$1,893.4	3.5%	8.5%	$2,228.9	$2,623.9	$3,089.0
Capital as % of Total	49.0%					
			Nominal % Growth :	17.7%	38.6%	63.1%
GRAND TOTALS :	$3,861.9	3.7%	8.7%	$4,562.1	$5,391.1	$6,373.0
			Nominal % Growth :	18.1%	39.6%	65.0%

* Row totals NOT always equal to sums of itemizations.
Row total figures reported separately by the institutions.

** Assuming 5% annual inflation

recognized and corrected quickly, the resultant losses would be felt for several decades. Left uncorrected, the deleterious effects of under-maintenance of the undergraduate science and research programs at the liberal arts colleges would be even greater and further protracted.

The 48 conference colleges have only three substantive general sources of revenue. The first is student tuition. Liberal arts colleges are highly tuition-dependent: income from this source typically provides 60% to 80% of the conference colleges' annual operating revenue. Already tuition costs for these private colleges are high, placing strains on students, their famillies, and institutional financial aid budgets. To compound this, these schools typically plan for one percent per annum real growth in tuition. Thus, little possibility exists for raising any substantive portion of the additional funds needed for science through additional real growth in tuition. This would result only in requiring more financial aid subsidies for a majority of their students, or decreasing the access to high quality private education and thus in further distancing this education from the means of many potential scientists. Finally, such tuition growth would place these institutions at serious cost disadvantage relative to competitors. In the era of declining enrollments and greatly intensifying competition, attempts to raise the required amounts of additional money for science from students and their famillies would likely have a detrimental net effect.

Another primary source of revenue is endowment. Some of these liberal arts colleges have large endowments. Others decidedly do not. For all schools, however, the ravages of the inflation of the 1970's, and of the general economics of higher education since then, have eroded the real values of endowments by as much as 15% to 20%. As a result, the proportion of total operating revenues which are endowment supported has declined over the last decade typically to less than 10% to 20%. To endow the future growth needed by these colleges for science would require very significant growth in endowment market values. Future capital campaigns and the largest gifts might reasonably be expected to cover some of the fixed costs, but not a large portion even of these. And no reasonable expectations of the abilities of these institutions to generate real endowment growth could approach the sums necessary to provide the full projected increases in costs for science.

The third revenue source is gifts from individual alumni and friends. Again, some real incremental growth may be obtained from these sources, but none sufficient to provide the required levels of funding. This is all the more obvious when also taking into account the myriad competing internal demands for such funds. Alumni, individually and corporately, do not possess wealth on this order, much less wealth which is unclaimed, waiting only for the alma mater to solicit it.

Preserving the undergraduate science education and research programs of these institutions will require expanded support from foundations and the development of genuinely new resources for these

colleges, new links with other sectors involved in American scientific progress, primarily those of government and industry.

The final chapter of this report presents and discusses methods to ensure that these colleges, and undergraduate science education generally, are able to meet their own future needs and those of the nation. Because government and industry are the only two sources of substantive support to American research and development, it is clear that these two sectors must be the ones to take up these crucial issues in close consort with the academic establishment, and particularly with the liberal arts colleges which historically have taken the leading role in undergraduate science in America. The primary needs are sufficient time and money for both faculty and students to conduct meaningful research while not diminishing significantly the high level of faculty-student contact essential to all aspects of science education and offered only in the environment of the liberal arts college.

Summary

* Research and development in America is experiencing a period of significant real growth, particularly the development area and defense-related R&D.

* Basic research, which is primarily conducted by the academic sector and forms the predominant R&D activity within this sector, is also experiencing substantial real growth.

* Business and industrial support, even for basic research nationally and for all R&D in the academic sector, is likewise in a period of significant expansion.

* These trends, however, are not affecting the liberal arts colleges, undergraduate science, or science education generally. For the liberal arts colleges, the primary trend has been the significant recent erosion of the federal support base which forms the only substantive source of the external funding necessary to maintain and strengthen undergraduate science education.

* This deleterious condition is developing at precisely the time when more and better-educated scientists at the undergraduate level are needed (and significantly fewer are available) to sustain future Ph.D. production in the sciences and generally to ensure the progress of fundamental research and the base of scientific knowledge. This knowledge and research are sine qua non to the nation's scientific future. They form the foundation for all future progress in applied research, in development and the national defense, and for enabling American success in the increasingly competitive and technological world economy.

* It also comes at a time when the real costs of undergraduate science education and research are projected to rise rapidly, beyond the means of these colleges to generate additional revenues to fund them.

* Genuinely new sources of funding for science at these liberal arts colleges must be developed, and fairly quickly, if the colleges' educational and research programs are to be maintained and their essential role in the undergraduate training of American scientists preserved.

* The primary needs are for sufficient time and money for both faculty and students to conduct meaningful research while not diminishing significantly the high level of faculty-student contact essential to all aspects of science education and offered only in the environment of the liberal arts college.

Sources - Chapter III

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2. Federal Funds for Research and Development, FY 1982, 1983, and 1984, National Science Foundation, 83-319.

3. Federal Support to Universities, Colleges, and Selected Non-Profit Institutions, FY 1978, 1979, 1981, and 1982, National Science Foundation, 84-315.

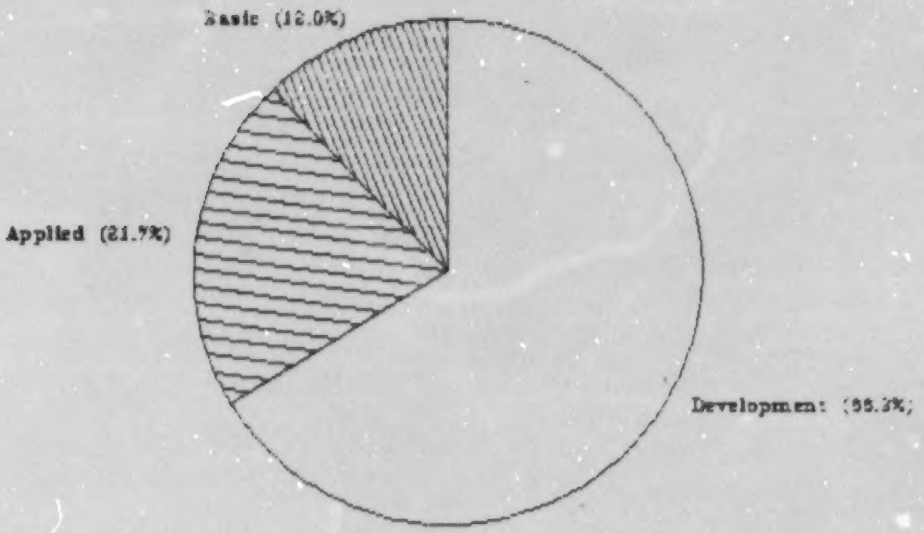
4. Keyworth, George A., "Mobilizing Science and Technology for America's Future," SUNY Research 1985, January-February, 1985, pp.3-6.

5. National Patterns of Science and Technology Resources, 1984, National Science Foundation, 84-311.

6. Science Indicators, 1982: An Analysis of the State of U.S. Science, Engineering, and Technology, National Science Board, 1983.

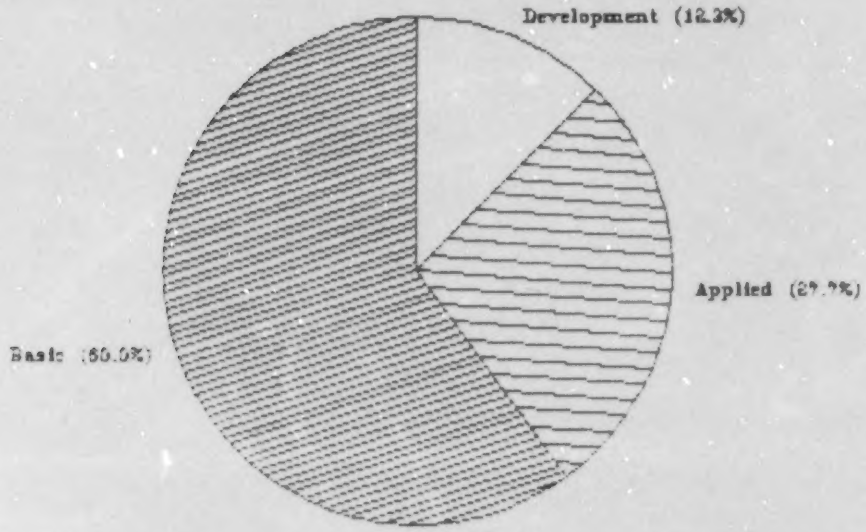
Graph I. A.

National Research & Development
By Type of Activity - FY 84



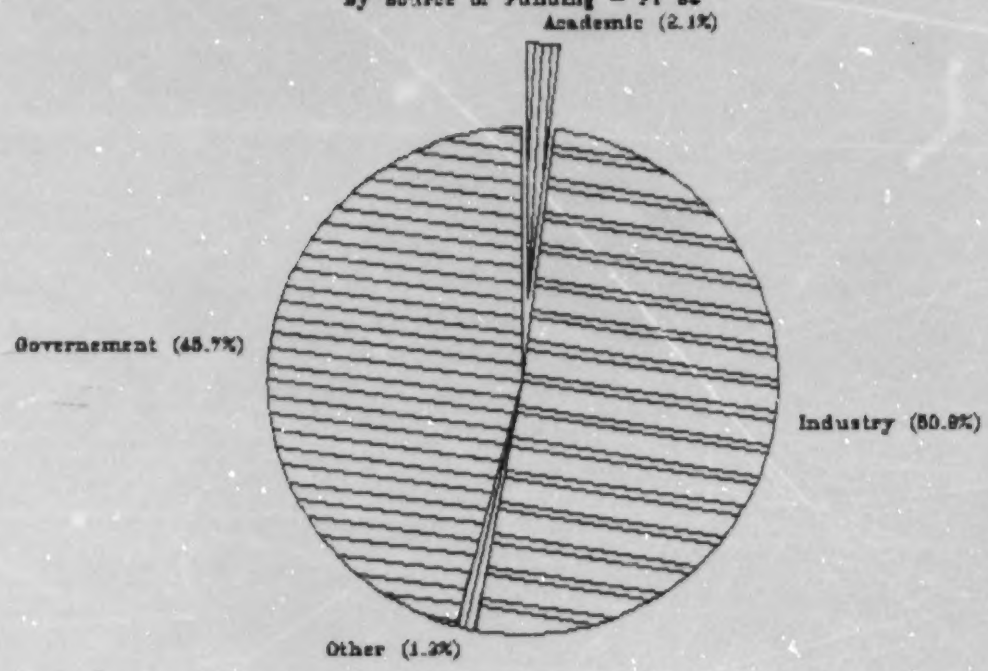
Graph I. B.

Academic Research & Development
By Type of Activity - FY 84



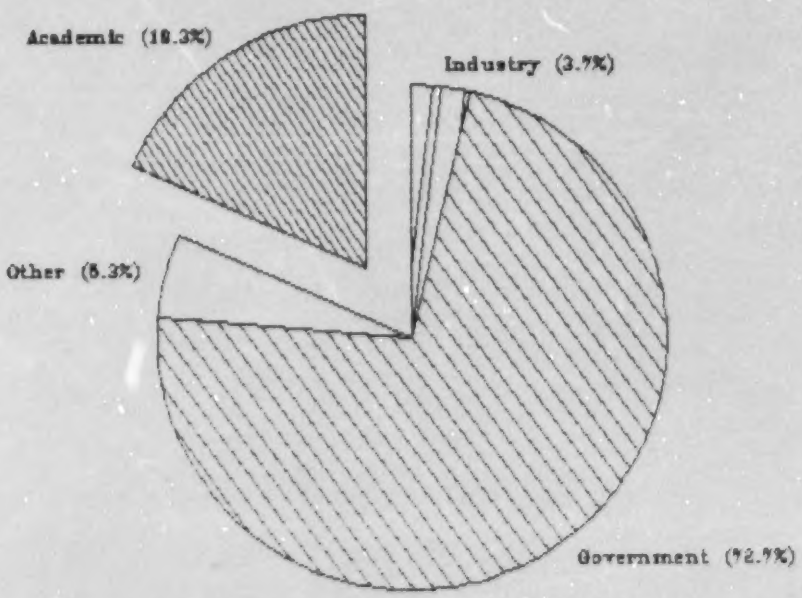
Graph II. A.

National Research & Development
By Source of Funding – FY 84



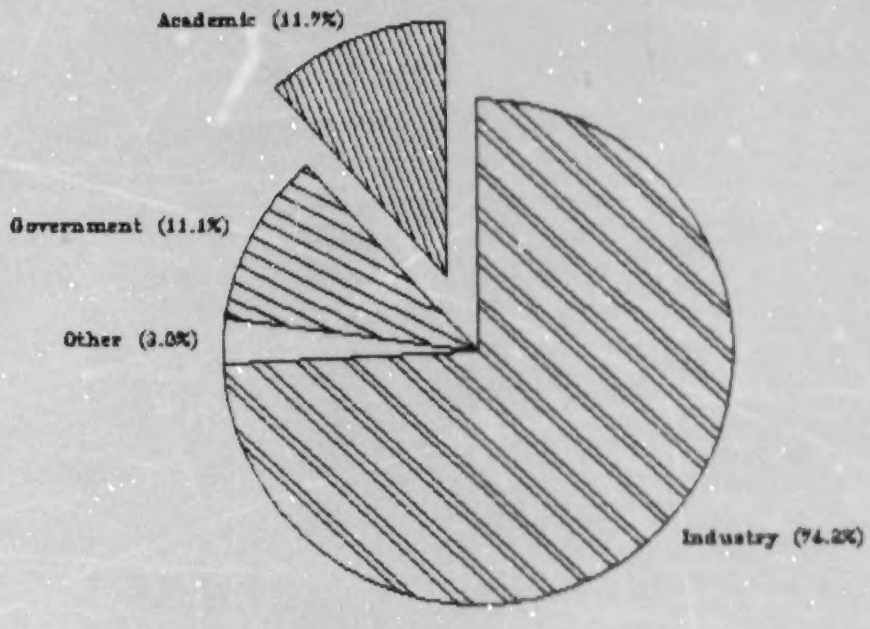
Academic Research & Development
By Source of Funding – FY 84

Graph II. B.



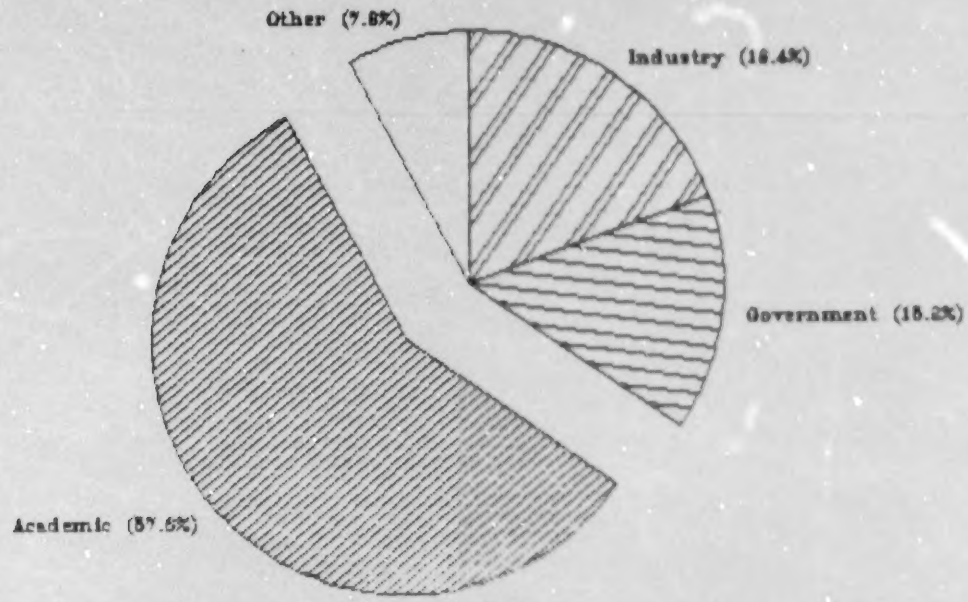
Graph III. A.

National Research & Development
By Sector of Performance - FY 84



Graph III. B.

National Basic Research
By Sector of Performance - FY 84



I. Total U.S. Research and Development Expenditures, By TYPE of ACTIVITY, 1960 to 1984

(Dollars in millions)

Fiscal Year	National R&D Total $ (in Mil.)	All Research: Basic Rsrch. $	Basic Rsrch. %	Applied Rsrch. $	Applied Rsrch. %	Development $	Development %
1960	$13,523	$1,197	8.9%	$3,020	22.3%	$9,306	68.8%
1965	$20,044	$2,555	12.7%	$4,339	21.6%	$13,150	65.6%
1970	$26,134	$3,549	13.6%	$5,720	21.9%	$16,865	64.5%
1975	$35,213	$4,608	13.1%	$7,863	22.3%	$22,742	64.6%
1980	$62,618	$8,089	12.9%	$14,060	22.5%	$40,469	64.6%
1983	$87,678	$10,610	12.1%	$19,897	22.7%	$57,171	65.2%
1984	$96,975	$11,850	12.2%	$21,400	22.1%	$63,725	65.7%
% Real* Growth 75 to 84	52.6%	42.5%		50.8%		55.2%	

Notes :

1. All research and development is composed of two-thirds development and one-third research.
2. Research further divides into basic and applied research, also approximately in a 1:2 ratio.
3. In the end, basic research comprises 12% of the national total R&D effort.
4. All three types of R&D are in a period of significant real growth, particularly development.

Sources : National Patterns of Science and Technology Resources 1984, NSF 84-311, Tables 1 through 12.

* based on GNP implicit price deflator; percent growths in 1972 constant dollars.

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II. Total U.S. Research and Development Expenditures, By SOURCES of FUNDING, 1960 to 1984

(Dollars in millions)

Fiscal Year	National R&D Total $ (in Mil.)	Federal Govt. $	Federal Govt. %	Business and Industry $	Business and Industry %	Academia $	Academia %	Other Non-Profit $	Other Non-Profit %
1960	$13,523	$8,738	64.6%	$4,516	33.4%	$149	1.1%	$120	.9%
1965	$20,044	$13,012	64.9%	$6,548	32.7%	$267	1.3%	$217	1.1%
1970	$26,134	$14,892	57.0%	$10,444	40.0%	$461	1.8%	$337	1.3%
1975	$35,213	$18,109	51.4%	$15,820	44.9%	$749	2.1%	$535	1.5%
1980	$62,618	$29,451	47.0%	$30,911	49.4%	$1,323	2.1%	$933	1.5%
1983	$87,678	$40,328	46.0%	$44,350	50.6%	$1,860	2.1%	$1,140	1.3%
1984	$96,975	$44,270	45.7%	$49,375	50.9%	$2,080	2.1%	$1,250	1.3%
% Real Growth 75 to 84	52.6%	35.4%		72.9%		53.8%		29.4%	

Notes :
1. Since 1960, industry has steadily funded an increasing percentage of the national total R&D effort.
2. Since 1980, it has surpassed the federal government by ever-increasing margins as the primary source of national R&D funding.
3. Funding for R&D provided by the academic sector has the second highest real growth rate (after that of industry).

Sources : National Patterns of Science and Technology Resources 1984, NSF 84-311, Tables 1 through 12.

III. Total U.S. Research and Development Expenditures, By Sector of PERFORMANCE, 1960 to 1984

(Dollars in millions)

Fiscal Year	National R&D Total $ (in Mil.)	Federal Gov't. $	Federal Gov't. %	Business and Industry $	Business and Industry %	Academia $	Academia %	Other Non-Profit $	Other Non-Profit %
1960	$13,523	$1,726	12.8%	$10,509	77.7%	$1,006	7.4%	$282	2.1%
1965	$20,044	$3,093	15.4%	$14,185	70.8%	$2,103	10.5%	$663	3.3%
1970	$26,134	$4,079	15.6%	$18,067	69.1%	$3,072	11.8%	$916	3.5%
1975	$35,213	$5,354	15.2%	$24,187	68.7%	$4,396	12.5%	$1,276	3.6%
1980	$62,618	$7,632	12.2%	$44,505	71.1%	$8,306	13.3%	$2,175	3.5%
1983	$87,678	$10,228	11.7%	$64,600	73.7%	$10,275	11.7%	$2,575	2.9%
1984	$96,975	$10,800	11.1%	$72,000	74.2%	$11,375	11.7%	$2,800	2.9%
% Real Growth 75 to 84	52.6%	11.7%		64.9%		43.3%		21.6%	

Notes :
1. The national R&D effort is performed by the various sectors very differently than it is funded by them (compare to Table II).
2. Industry performs three-quarters of all R&D, and has been increasing this percentage steadily.
3. The academic sector is the second largest performer of R&D in America, and exhibits the second largest real growth rate in its performance.

Sources : National Patterns of Science and Technology Resources 1984, NSF 84-311, Tables 1 through 12.

IV. Expenditures for All Research and Development Conducted in the ACADEMIC SECTOR, By TYPE of ACTIVITY, 1960 to 1984

(Dollars in millions)

Fiscal Year	Academic R&D Total* $ (in Mil.)	All Research: Basic Rsrch. $	Basic Rsrch. %	All Research: Applied Rsrch. $	Applied Rsrch. %	Development $	Development %
1960	$1,006	$530	52.7%	$301	29.9%	$175	17.4%
1965	$2,103	$1,346	64.0%	$483	23.0%	$274	13.0%
1970	$3,072	$2,065	67.2%	$643	20.9%	$364	11.8%
1975	$4,396	$2,719	61.9%	$1,115	25.4%	$562	12.8%
1980	$8,306	$4,812	57.9%	$2,391	28.8%	$1,103	13.3%
1983	$10,275	$6,035	58.7%	$2,920	28.4%	$1,320	12.8%
1984	$11,375	$6,825	60.0%	$3,150	27.7%	$1,400	12.3%
% Real Growth 75 to 84 :	43.3%	39.1%		56.5%		38.0%	

Notes :
1. In the academic sector, the various types of R&D are performed in very different proportion than nationally (compare to Table I).
2. Here, BASIC RESEARCH is the dominant type (60%), and all research comprises nearly 90% of the total R&D activity of this sector.
3. In the academic sector, barely more than 10% of the R&D effort is development (and this development is performed almost entirely in the FFRDC's).

* Including Federally-Financed Research and Development Centers (FFRDC's)

Sources : National Patterns of Science and Technology Resources 1984, NSF 84-311, Tables 1 through 12.

V. Total U.S. Expenditures for BASIC Research
By SOURCES of FUNDING, 1960 to 1984

(Dollars in millions)

Fiscal Year	Basic Research National Total $ (in Mil.)	Federal Govt. $	Federal Govt. %	Business and Industry $	Business and Industry %	Academia $	Academia %	Other Non-Profit $	Other Non-Profit %
1960	$1,197	$715	59.7%	$342	28.6%	$72	6.0%	$68	5.7%
1965	$2,555	$1,809	70.8%	$461	18.0%	$164	6.4%	$121	4.7%
1970	$3,549	$2,489	70.1%	$528	14.9%	$350	9.9%	$182	5.1%
1975	$4,608	$3,139	68.1%	$705	15.3%	$478	10.4%	$286	6.2%
1980	$8,089	$5,559	68.7%	$1,265	15.6%	$805	10.0%	$460	5.7%
1983	$10,610	$6,970	65.7%	$2,025	19.1%	$1,075	10.1%	$540	5.1%
1984	$11,850	$7,775	65.6%	$2,270	19.2%	$1,220	10.3%	$585	4.9%
% Real Growth 1975 to 84:	40.6%	34.9%		79.0%		38.4%		12.6%	

Notes :
1. The national basic research effort is funded primarily (two-thirds) by the federal government.
2. While industry currently funds only one-fifth of all basic research, it is increasing this support at a very rapid rate in real terms, and thus, is funding a steadily and significantly increasing portion of all basic research.
3. The academic sector can fund only 10% of the national basic research effort from internal monies.

Sources : National Patterns of Science and Technology Resources 1984, NSF 84-311, Tables 1 through 12.

VI. Total U.S. Expenditures for BASIC Research
By Sector of PERFORMANCE, 1960 to 1984

(Dollars in millions)

Fiscal Year	Basic Research National Total $ (in Mil.)	Federal Govt. $	Federal Govt. %	Business and Industry $	Business and Industry %	Academia * $	Academia * %	Other Non-Profit $	Other Non-Profit %
1960	$1,197	$160	13.4%	$376	31.4%	$530	44.3%	$131	10.9%
1965	$2,555	$364	14.2%	$592	23.2%	$1,346	52.7%	$253	9.9%
1970	$3,549	$577	16.3%	$602	17.0%	$2,065	58.2%	$305	8.6%
1975	$4,608	$734	15.9%	$730	15.8%	$2,719	59.0%	$425	9.2%
1980	$8,089	$1,182	14.6%	$1,325	16.4%	$4,812	59.5%	$770	9.5%
1983	$10,610	$1,650	15.6%	$2,050	19.3%	$6,035	56.9%	$875	8.2%
1984	$11,850	$1,800	15.2%	$2,300	19.4%	$6,825	57.6%	$925	7.8%
% Real Growth 1975 to 84	42.5%	35.9%		74.5%		39.1%		20.6%	

Notes :
1. Basic research, as is the total R&D effort, is performed very differently than it is funded (compare above to Table V).
2. The academic sector is far and away the primary locus for the national basic research effort, performing nearly 60% of all basic research.
3. Industry both funds and conducts approximately one-fifth of all basic research.

* Including Federally-Financed Research and Development Centers (FFRDC's)

Sources : National Patterns of Science and Technology Resources 1984, NSF 84-311, Tables 1 through 12.

VII. Expenditures for BASIC Research Conducted in the ACADEMIC SECTOR By SOURCES of FUNDING, 1960 to 1984

(Dollars in millions)

Fiscal Year	Total Spent for Basic Research, Academic Sector* $ (in Mil.)	Federal Govt. $	Federal Govt. %	Business and Industry $	Business and Industry %	Academia $	Academia %	Other Non-Profit $	Other Non-Profit %
1960	$530	$396	74.7%	$24	4.5%	$72	13.6%	$38	7.2%
1965	$1,346	$1,087	80.8%	$26	1.9%	$164	12.2%	$69	5.1%
1970	$2,065	$1,565	75.8%	$40	1.9%	$350	16.9%	$110	5.3%
1975	$2,719	$2,003	73.7%	$72	2.6%	$478	17.6%	$166	6.1%
1980	$4,812	$3,637	75.6%	$135	2.8%	$805	16.7%	$235	4.9%
1983	$6,035	$4,425	73.3%	$225	3.7%	$1,075	17.8%	$310	5.1%
1984	$6,625	$5,005	73.3%	$260	3.8%	$1,220	17.9%	$340	5.0%
% Real Growth 1975 to 84	39.1%	38.4%		100.0%		41.4%		13.5%	

Notes :

1. The federal government is the primary source of funding for basic research conducted in the academic sector. It has steadily supplied three-quarters of all such funding.
2. Industrial support, though small, has been increasing significantly and steadily since 1970. Since 1975, the industrial dollar amount has grown 100% in constant dollars.
3. As a result, the percentage of academic basic research which is industrially supported has DOUBLED since 1970.
4. Nevertheless, while industry funds 20% of all basic research, it funds less than 4% of all basic research conducted in the academic sector.

* Including Federally-Financed Research and Development Centers (FFRDC's)

Sources : National Patterns of Science and Technology Resources 1984, NSF 84-311, Tables 1 through 12.

VIII. Expenditures for All Research and Development Conducted in the ACADEMIC SECTOR By SOURCES of FUNDING, 1960 to 1984

(Dollars in millions)

Fiscal Year	Academic R&D Total* $ (in Mil.)	Federal Govt. $	Federal Govt. %	Business and Industry $	Business and Industry %	Academia $	Academia %	Other Non-Profit $	Other Non-Profit %
1960	$1,006	$765	76.0%	$40	4.0%	$149	14.8%	$52	5.2%
1965	$2,103	$1,702	80.9%	$41	1.9%	$267	12.7%	$93	4.4%
1970	$3,072	$2,385	77.6%	$61	2.0%	$461	15.0%	$165	5.4%
1975	$4,396	$3,275	74.5%	$113	2.6%	$749	17.0%	$259	5.9%
1980	$8,306	$6,340	76.3%	$235	2.8%	$1,323	15.9%	$408	4.9%
1983	$10,275	$7,500	73.0%	$375	3.6%	$1,860	18.1%	$540	5.3%
1984	$11,375	$8,270	72.7%	$425	3.7%	$2,080	18.3%	$600	5.3%
% Real Growth 1975 to 84	43.3%	39.9%		108.4%		53.8%		28.3%	

Notes :

1. The federal government is the primary source of funding for all R&D conducted in the academic sector. It has steadily supplied three-quarters of all funding for academic R&D.
2. Industrial support, though small, has been increasing significantly and steadily since 1970. Since 1975, it has more than doubled in real terms.
3. As a result, the percentage of academic total R&D which is industrially supported has nearly doubled since 1970.
4. Nevertheless, while industry funds 51% of the national total R&D effort, it funds less than 4% of all R&D conducted in the academic sector.

* Including Federally-Financed Research and Development Centers (FFRDC's)

Sources : National Patterns of Science and Technology Resources 1984, NSF 84-311, Tables 1 through 12.

IX. Total Federal Support, and Key Federal Supports for Science, Awarded to All Academic Institutions, to the 100 Receiving the Largest Amounts for Science, to all Doctorate-Granting Institutions (N=353), and to the 48 Liberal Arts Colleges, Fiscal Years 1978 to 1982.

Type of Funding	FY	All Institutions	100 Top-Funded In Science $	100 Top-Funded In Science %	All 353 Doctorate-Granting $	All 353 Doctorate-Granting %	The 48 Liberal Arts Colleges $	The 48 Liberal Arts Colleges %
All Fed. Support to Educ.	78	$7,479.177	$4,239.803	56.7%	$5,512.342	73.7%	$44.608	.60%
	82	$8,702.380	$5,319.180	61.1%	$6,633.467	76.2%	$47.513	.55%
Federal Sci/Eng	78	$3,957.638	$3,226.203	81.5%	$3,824.451	96.6%	$10.777	.27%
	82	$5,245.484	$4,352.276	83.0%	$5,104.911	97.3%	$10.710	.20%
Federal R&D	78	$3,362.174	$2,782.861	82.8%	$3,285.894	97.7%	$7.682	.23%
	82	$4,552.543	$3,844.582	84.4%	$4,475.760	98.3%	$9.531	.21%
NSF	78	$607.119	$488.702	80.5%	$576.592	95.0%	$5.300	.87%
	82	$728.020	$622.778	85.5%	$718.457	98.7%	$2.758	.38%
Facil. & Instrum.	78	$26.664	$20.000	75.0%	$25.107	94.2%	$.228	.86%
	82	$.829	$.753	90.8%	$.829	100.0%	$.000	.00

Notes :

1. The two sets, top-funded research universities and all doctorate-granting institutions, receive federal support for science in significant disproportion to their total federal funding receipts.
2. This imbalance has recently been increasing.
3. The 48 liberal arts colleges have experienced significant reductions in both total federal support and federal support for science as measured either in real dollars or as percentages of the total federal supports to all institutions.
4. By far the most serious reductions have occured in NSF funding to these colleges.

Source : Federal Support to Universities, Colleges and Selected Non-Profit Institutions, FY 1978 and FY 1982. NSF 80-312, NSF 84-315.

Chapter IV

Recommendations

> "In summing my own experiences over all of these academmic institutions, I'm firmly convinced that, at the undergraduate level, a liberal arts degree program is the preferred way to go. On numerous occasions I have found myself counselling even those students who are highly focused in the science/technology area to pursue a liberal arts degree prior to specializing in graduate school. I also feel that the quality of education and stimulation found in the select small liberal arts colleges to be unparalleled during this crucial developmental period."
>
> — David A. Evans, Professor of Chemistry
> Harvard University (Oberlin)

This report amply demonstrates that the future of American science rests heavily upon the vitality of a relatively small number of the nation's leading undergraduate colleges.

These colleges, selected on the basis of their record of attracting and educating the best of America's future scientists, could be called **"research colleges."**

Research colleges share an important characteristic — excellent students learning from productive practicing scientists, scientists who view undergraduate collaboration in their research programs as indispensible to their roles as teachers of science and practitoners of science. This is the vital distinction. These scientist-educators conduct research not only to advance knowledge, but also to educate their undergraduate students.

Unlike most of their colleagues at the leading universities, these college faculty collaborate with undergraduates, students who will subsequently enter graduate institutions and become themselves the nation's scientists. Unlike their colleagues at other colleges, these faculty teach science by doing science, not only by describing facts and methods.

Active involvement in research is necessary to maintain the pedagogical excellence that characterizes the research college. Scholarly work on the frontiers of knowledge, at the cutting edge of

science, stimulates excitement about the faculty member's discipline. Scientific research is an ongoing conversation between the scientific community and nature, a conversation that enlivens the individual scientist. The scientist-educator brings to teaching the results of that conversation, and its personal excitement. Thus, teaching is most effective when informed and enlivened by an active research program.

The report assesses the past productivity of the nation's leading undergraduate private colleges, their current vitality, and the challenges they face in the education of future generations of the nation's scientists. Past investments, by these institutions and by external agencies, have had an enormous impact. Scientific knowledge has been advanced, leading scientists have been educated, and society's leaders exposed to scientific and technological issues. Here we present recommendations designed to strengthen science education at these institutions.

We recognize that while the conference institutions play a critically important role, America's continued leadership in science and technology also depends upon the essential contributions made by elementary, secondary, and graduate institutions. In turn, the effectiveness of the graduate institutions depends upon the health of this handful of undergraduate colleges. If these colleges are sapped of their ability to conduct research, to sustain effective teaching, and thus to provide an important cadre of graduate students, no amount of investment in the universities can compensate.

These recommendations are divided into four broad groups: 1) preparation, 2) curriculum and program, 3) funding needs, and 4) renewal strategy. Some of these recommendations are directed internally, toward our campuses themselves; others are directed externally, toward other participants in American science education.

I. Preparation

1. Renewed emphasis should be placed on science and mathematics education at the elementary and secondary schools. The conference colleges' efforts depend upon the quality and preparation of our entering students. They waste the nation's resources when they teach the science and mathematics that should have been learned earlier. The kindling and growth of scientific interest begins early. Such interest is fragile, and can be easily extinguished by ineffective teaching. Instruction in scientific and mathematical facts is not enough. Development of observational skills and the creative imagination and reasoning capacity involved in experimental design and interpretion if results are vital to the impulse toward scientific work. Regular laboratory experience, begun as early as possible, is a critical part of elementary and secondary science education. Mathematics education is central and should now include some discrete mathematics. Computing should be introduced as early as possible. Just as with the college and university faculties, elementary and secondary educators must be adequately trained, motivated, developed and compensated.

II. Curriculum and Programs

These recommendations are necessarily general; they should serve as a starting point for institutional self-studies. Effective program development and review is a central element of institutional accountability and, therefore, of credibility. The data developed in the conference report provide a comparative context for these studies.

2. Planning should be improved both at the departmental and divisional levels. Curricular responses to new and rapidly changing scientific disciplines must be developed under realistic staffing constraints. The growth of knowledge requires that courses and majors be reviewed regularly, with choices made about the emphasis at the undergraduate level. Areas that need attention include: immunology, molecular genetics, neurosciences, bio-organic and bio-inorganic chemistry, chemical physics, geophysics, discrete mathematics, computer science, astrophysics, and cosmology. Cooperation among departments regarding both curriculum and resources is essential.

3. New curricular opportunities for student participation in research must be created. A distinctive strength of the research college is the integration of students into faculty research programs as apprentice scientists. These apprenticeships must be more deeply woven into the curricular fabric, including for example, creation of "research courses" which encompass student participation in faculty research, and which are included in faculty load calculations. The research group is a natural vehicle for such a course. Research experience, however, cannot responsibly substitute for the core content of the major.

4. Science education for non-science majors should emphasize direct engagement with the process of scientific inquiry as well as with scientific knowledge. Broad appreciation of the impact on society of science, both basic and applied, is important to a well-informed citizenry. The general education component of science instruction should facilitate understanding of that impact, and ideally should include laboratory experiences. Computer simulations should be integrated into the curriculum, but must not substitute for direct observation of natural phenomena. Opportunities for teaching with colleagues from other divisions should be encouraged.

5. Student writing and computing skills should be refined at all levels of the curriculum. Communication of results is too important to be assigned to other areas of the curriculum. Development of writing ability should be an integral part of the science curriculum. Computing in its broadest sense is likewise so fundamental that it must be incorporated into science courses, with particular attention to modeling.

6. Computer science should be recognized as a separate scientific discipline. Computer science has now established itself as a legitimate and distinct discipline, although one still rapidly evolving. Creation of a separate major should be carefully considered at those research colleges not now offering one, and recognition should be given to the discipline through the development of administrative

structures appropriate to each campus. The fierce competition for computer scientists will necessitate especially vigorous faculty recruitment.

III. Funding Needs

Among the conference institutions there is considerable variability in both internal and external funding for the sciences. The recommendations presented next are generic; they must be adapted to the particular circumstances of each campus. That adaptation, and the wise and effective allocation of resources, is the responsibility of campus-based budget and planning structures.

a) The recruitment of new faculty, and the continued development of all faculty, are prerequisite for effective science education. The research college competes directly with the leading research universities and with industry for talented scientists. Concerted efforts are necessary if these colleges are to recruit and retain exceptional scientist-educators.

7. Competitive salary levels must be established and maintained. Compensation must not be a determinative factor in the selection of the type of institution in which a faculty member establishes or continues a career.

8. "Starter grants" should be sufficient to enable new faculty to develop competitive research programs. Depending upon the discipline, a minimum initial institutional investment of $20,000 for establishing a research program may be required to supplement funding from external sources. Some fields will require an average of $50,000. In universities grants exceeding $100,000 are common.

9. Research leaves during the probationary period should be encouraged, and funded by the institution if necessary. Since a mastery of teaching and the ability to develop and maintain an independent research program must be demonstrated prior to the tenure decision, a leave should be granted during the probationary period. Such a leave would be beneficial to all junior faculty, and especially so for those without formal postdoctoral training.

10. Faculty development activities should be adequately funded. Conference and workshop attendance, colloquia, and other activities keep research college faculty in close contact with their disciplinary colleagues at universities and in industry. External grants should be the primary source of funding, with internal funding provided if required. Released time facilitates curriculum development.

11. Regular sabbatical and flexible short-term leaves should be enhanced. Sabbatical leaves taken in outstanding laboratories or at the home campus provide an excellent opportunity for concentrated research. Greater flexibility with short-term leaves would enable creative use of faculty time and provide additional opportunities to acquire new techniques between regular sabbaticals.

12. Communication among colleagues should be improved, particularly with those at other research colleges. The disciplinary associations provide an excellent means of communication. Yet the division of these associations into specialized subfields means that scientist-educators at the research colleges rarely discuss matters of mutual interest. Appropriate national structures for such communication, both via electronic mail and in person, should continue to be developed. The Councils on Undergraduate Research established in chemistry and physics are good examples of such structures.

13. Funding for significantly expanded research opportunities for students, both during the academic year and summer, should be obtained. Student participation in faculty research programs is the hallmark of the research college. Academic year stipends should equal or exceed campus job expectations of the financial aid package. Summer research assistantships should be superior to other employment opportunities so that loan obligations can be minimized.

14. Institutions should assist their faculty in grant development, preparation, and placement. Providing budgetary expertise and clerical assistance can often make the difference between an accepted and a rejected proposal.

15. Regular review and evaluation of faculty productivity, coupled with individual career planning, is essential for the long-term vitality of the science faculty as a whole. Because of the rapid change in the sciences, these customary institutional practices are all the more necessary in the sciences.

b) Scientific teaching and research requires more than excellent scientist-educators — they require laboratories, instrumentation, computing, libraries, and technical support personnel. We have assumed that major building needs will be reviewed on individual campuses, and that building planning will proceed effectively. Particular care should be given to the adequacy of safety features: fume hoods, radioactive waste disposal, and biohazard protection. The next set of recommendations are aimed at the remaining infrastructure.

16. Substantial infusion of capital is required for the ongoing replacement of existing laboratory equipment and for the acquisition of new instrumentation. While deferred building maintenance has been identified as a major institutional concern, too little attention has been given to aging laboratory equipment and the continuing need to update existing facilities. Obsolete laboratory equipment should be replaced immediately and adequate allocations made to scientific equipment renewal and replacement funds on an annual and ongoing basis. State-of-the-art research instrumentation must be acquired at an accelerated pace.

17. Additional equipment maintenance and technical support personnel should be hired. Real need exists for machine and electronics shops; these can be centralized when appropriate and shared among several disciplines. Departmental technicians can provide important and effective assistance with laboratory setup and instruction.

18. Computing applications must be more rapidly addressed. The importance of computing to scientific endeavors has long been recognized. The rapid expansion of this technology to other areas may mask the continuing need for computing in the sciences. Key to these developments will be an effective campus telecommunications network linking computing resources across the campus and linking the campus to other institutions, particularly to large mainframes and supercomputers for computation-intensive research. A second essential element is the acquisition of individual microcomputer workstations having high resolution graphics. Microcomputer-based data acquistion and analysis equipment must be prominent in laboratories. Classrooms should be equipped with computer video projection equipment in the near future. Finally, there must be adequate support personnel for software development and implementation.

19. Enhance library resources. As scientific knowledge accelerates, so does the demand on the library. Care must be taken to make wise acquisition decisions so as to provide adequate journal and monograph collections. Access to reference materials increasingly takes the form of national electronic databases, and steps must be taken to ensure adequate retrieval from these sources. There may well be substantial opportunities for institutional cooperation through computer networks that should be carefully investigated.

IV. Renewal Strategies

We recognize that the needs identified here will require substantial funds as well as effort. Despite the strong financial condition and sound resource base of the conference colleges, the individual efforts of these institutions alone will not be able to meet the needs. They will require external assistance. The investment in scientific knowledge properly serves global needs; it is equally proper that it serve the national interest by strengthening science education and broadening the population that has scientific expertise. The faculty at research colleges play a triple role — they are active and effective research scientists, they are lucid and stimulating educators of future scientists, and they are important to providing the general scientific education of future leaders of society. The recommendations that follow are aimed at renewing the scientific vitality at this national resource, the research college.

20. Those responsible for federal research and development expenditures should recognize that although the pace of research at our colleges may be slower, its quality is fully competitive with that at universities. Several consequences follow. Firstly, it is important that federal funding for research be reasonably stable, particularly in programs directed toward leading research colleges. Secondly, grant peer-review panels should include significant representation from the leading undergraduate institutions. Our faculty can compete successfully, if quality, rather than the pace of research, is the fundamental consideration in peer-review panels.

21. The National Science Foundation should propose, and Congress approve, a grant program similar to the NEH Challenge program. Challenge grants provide exceptional opportunities for financial leverage of federal R&D expenditures. The NEH program provides a suitable, and successful, model that should be extended to the sciences. The Challenge Grant process is educative; it alerts alumni and other donors to the needs of the sciences. It also allows each college to identify and articulate its most pressing needs. Nationally, it insures an intelligent and rigorous review of overall science education requirements.

22. Within federal agencies, notably the National Science Foundation, there must be effective coordination between research and education activities. Too often a strict dichotomy is drawn between educational and research support programs. Funding agencies must recognize the intimate relationship between teaching and research at the leading undergraduate institutions and encourage proposals that involve significant student participation in research.

23. There should be improved cooperation between the research colleges and industry. Corporate support of academic R&D has been overly restricted to the major research universities. Corporate partnership with the research colleges would be an effective means of improving national scientific productivity. Programs might include: direct grants, exchange of personnel, and the transfer of technology from the corporate-university environment to that of smaller organizations.

24. Foundations should develop programs that support innovative, integrated efforts at the research colleges. Foundations have traditionally provided venture capital to stimulate creative responses to the needs of the nation's colleges and universities. They should continue these efforts, and be particularly receptive to initiatives that support faculty-student research.

Appendix A: National Patterns of Enrollment

National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in the Basic Sciences
1975, 1979 and 1984

	2-Year Colleges			4 - Y e a r C o l l e g e s									U n i v e r s i t i e s							
				Public			Private Non-Sectarian			Priv. Sec.		4-YR.	Public			Private			UNIV.	NATIONAL
	Public	Priv.	2-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.	COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total	TOTAL	GRAND TOTAL
1 9 8 4:																				
N Frosh.	531,939	74,751	606,690	316,797	44,643	361,440	87,687	47,221	134,908	93,430	50,270	640,048	223,104	72,663	295,767	63,063	29,653	92,716	388,483	1,635,221
% Share	32.5%	4.6%	37.1%	19.4%	2.7%	22.1%	5.4%	2.9%	8.3%	5.7%	3.1%	39.1%	13.6%	4.4%	18.1%	3.9%	1.8%	5.7%	23.8%	100.0%
% Science	4.4%	3.8%	4.3%	6.0%	10.8%	6.6%	5.7%	14.0%	8.6%	7.9%	7.6%	7.3%	6.9%	12.5%	8.2%	9.6%	17.4%	12.1%	9.2%	6.6%
N Science	23,405	2,870	26,276	19,008	4,821	23,829	4,980	6,603	11,583	7,381	3,821	46,614	15,344	9,049	24,392	6,061	5,157	11,217	35,610	108,499
Share of Science	21.6%	2.6%	24.2%	17.5%	4.4%	22.0%	4.6%	6.1%	10.7%	6.8%	3.5%	43.0%	14.1%	8.3%	22.5%	5.6%	4.8%	10.3%	32.8%	100.0%
1 9 7 9:																				
N Frosh.	619,918	60,850	680,768	319,253	48,274	367,527	79,336	48,052	127,388	99,992	56,719	651,626	226,960	71,536	298,496	55,131	27,123	82,254	380,750	1,713,144
% Share	36.2%	3.6%	39.7%	18.6%	2.8%	21.5%	4.6%	2.8%	7.4%	5.8%	3.3%	38.0%	13.2%	4.2%	17.4%	3.2%	1.6%	4.8%	22.2%	100.0%
% Science	4.6%	3.2%	4.5%	6.1%	11.4%	6.8%	7.6%	15.1%	10.4%	8.4%	9.7%	8.0%	6.8%	12.0%	8.0%	8.9%	17.7%	11.8%	8.8%	6.8%
N Science	28,516	1,947	30,463	19,539	5,525	25,064	6,033	7,269	13,301	8,399	5,502	52,266	15,382	8,594	23,975	4,896	4,794	9,691	33,666	116,396
Share of Science	24.5%	1.7%	26.2%	16.8%	4.7%	21.5%	5.2%	6.2%	11.4%	7.2%	4.7%	44.9%	13.2%	7.4%	20.6%	4.2%	4.1%	8.3%	28.9%	100.0%
1 9 7 5:																				
N Frosh.	687,029	53,218	740,247	296,216	50,744	346,960	65,929	50,835	116,764	104,904	49,607	618,235	251,343	64,153	315,496	57,676	28,876	86,552	402,048	1,760,530
% Share	39.0%	3.0%	42.0%	16.8%	2.9%	19.7%	3.7%	2.9%	6.6%	6.0%	2.8%	35.1%	14.3%	3.6%	17.9%	3.3%	1.6%	4.9%	22.8%	100.0%
% Science	5.7%	4.1%	5.6%	9.6%	14.8%	10.4%	9.1%	20.9%	14.3%	12.2%	14.2%	11.7%	11.5%	19.4%	13.1%	19.9%	26.3%	22.0%	15.1%	9.9%
N Science	39,374	2,198	41,572	28,554	7,526	36,080	5,993	10,648	16,641	12,850	7,064	72,634	28,983	12,464	41,447	11,465	7,603	19,068	60,515	174,721
Share of Science	22.5%	1.3%	23.8%	16.3%	4.3%	20.6%	3.4%	6.1%	9.5%	7.4%	4.0%	41.6%	16.6%	7.1%	23.7%	6.6%	4.4%	10.9%	34.6%	100.0%

National Patterns of Enrollment, by Institutional Typology :
Freshman Declaring Prospective Majors in the Basic Sciences
1975, 1979 and 1984

Summary Table

Changes in Enrollments	2-Year Colleges			4-Year Colleges									Universities							
				Public			Private Non-Sectarian			Priv. Sec.		4-YR. COL. TOTAL	Public			Private			UNIV. TOTAL	NATIONAL GRAND TOTAL
	Public	Priv.	2-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.		L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total		
Share of All Frosh. Enrlmnt.																				
1984	32.5%	4.6%	37.1%	19.4%	2.7%	22.1%	5.4%	2.9%	8.3%	5.7%	3.1%	39.1%	13.6%	4.4%	18.1%	3.9%	1.8%	5.7%	23.8%	100.0%
1979	36.2%	3.6%	39.7%	18.6%	2.8%	21.5%	4.6%	2.8%	7.4%	5.8%	3.3%	38.0%	13.2%	4.2%	17.4%	3.2%	1.6%	4.8%	22.2%	100.0%
1975	39.0%	3.0%	42.0%	16.8%	2.9%	19.7%	3.7%	2.9%	6.6%	6.0%	2.8%	35.1%	14.3%	3.6%	17.9%	3.3%	1.6%	4.9%	22.8%	100.0%
% Change :	-16.6%	51.2%	-11.8%	15.1%	-5.3%	12.2%	43.2%	.0	24.4%	-4.1%	9.1%	11.5%	-4.4%	21.9%	.9%	17.7%	10.6%	15.3%	4.0%	.0
% of Frosh with Science as Major																				
1984	4.4%	3.8%	4.3%	6.0%	10.8%	6.6%	5.7%	14.0%	8.6%	7.9%	7.6%	7.3%	6.9%	12.5%	9.2%	9.6%	17.4%	12.1%	9.2%	6.6%
1979	4.6%	3.2%	4.5%	6.1%	11.4%	6.8%	7.6%	15.1%	10.4%	8.4%	9.7%	8.0%	6.8%	12.0%	8.0%	8.9%	17.7%	11.8%	8.8%	6.8%
1975	5.7%	4.1%	5.6%	9.6%	14.8%	10.4%	9.1%	20.9%	14.3%	12.2%	14.2%	11.7%	11.5%	16.4%	13.1%	19.9%	26.3%	22.0%	15.1%	9.9%
% Change :	-23.2%	-7.0%	-22.9%	-37.8%	-27.2%	-36.6%	-37.5%	-33.2%	-39.8%	-35.5%	-46.6%	-38.0%	-40.4%	-35.9%	-37.2%	-51.7%	-33.9%	-45.1%	-39.1%	-33.1%
Share of Science Market																				
1984	21.6%	2.6%	24.2%	17.5%	4.4%	22.0%	4.6%	6.1%	10.7%	6.8%	3.5%	43.0%	14.1%	8.3%	22.5%	5.6%	4.8%	10.3%	32.8%	100.0%
1979	24.5%	1.7%	26.2%	16.8%	4.7%	21.5%	5.2%	6.2%	11.4%	7.2%	4.7%	44.9%	13.2%	7.4%	20.6%	4.2%	4.1%	8.3%	28.9%	100.0%
1975	22.5%	1.3%	23.8%	16.3%	4.3%	20.6%	3.4%	6.1%	9.5%	7.4%	4.0%	41.6%	16.6%	7.1%	23.7%	6.6%	4.4%	10.9%	34.6%	100.0%
% Change :	-4.3%	110.3%	1.8%	7.2%	3.2%	6.4%	33.8%	-.1%	12.1%	-7.5%	-12.9%	3.3%	-14.7%	16.9%	-5.2%	-14.9%	9.2%	-5.3%	-5.2%	.0

Sources: "The American Freshman: National Norms for Fall, 1984"
Astin, Green, Korn and Maier, American Council on Education, 1984
"The American Freshman: National Norms for Fall, 1979"
Astin, King and Richardson, American Council on Education, 1979
"The American Freshman: National Norms for Fall, 1975"
Astin, King, Light and Richardson, American Council on Education, 1975

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National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in the Basic Sciences
1975, 1979 and 1984

N.B.: Four-Year Institutions Only

	4-Year Colleges									Universities							
	Public			Private Non-Sectarian			Priv. Sec.		4-YR. COL. TOTAL	Public			Private			UNIV. TOTAL	NATIONAL GRAND TOTAL
	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.		L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total		
1984:																	
N Frosh.	316,797	44,643	361,440	87,687	47,221	134,908	93,430	50,270	640,048	223,104	72,663	295,767	63,063	29,653	92,716	388,483	1,028,531
% Share	30.8%	4.3%	35.1%	8.5%	4.6%	13.1%	9.1%	4.9%	62.2%	21.7%	7.1%	28.8%	6.1%	2.9%	9.0%	37.8%	100.0%
% Science	6.0%	10.8%	6.6%	5.7%	14.0%	8.6%	7.9%	7.6%	7.3%	6.9%	12.5%	8.2%	9.6%	17.4%	12.1%	9.2%	8.0%
N Science	19,008	4,821	23,829	4,980	6,603	11,583	7,381	3,821	46,614	15,344	9,049	24,392	6,061	5,157	11,217	35,610	82,224
Share of Science	23.1%	5.9%	29.0%	6.1%	8.0%	14.1%	9.0%	4.6%	56.7%	18.7%	11.0%	29.7%	7.4%	6.3%	13.6%	43.3%	100.0%
1979:																	
N Frosh.	319,253	48,274	367,527	79,336	48,052	127,388	99,992	56,719	651,626	226,960	71,536	298,496	55,131	27,123	82,254	380,750	1,032,376
% Share	30.9%	4.7%	35.6%	7.7%	4.7%	12.3%	9.7%	5.5%	63.1%	22.0%	6.9%	28.9%	5.3%	2.6%	8.0%	36.9%	100.0%
% Science	6.1%	11.4%	6.8%	7.6%	15.1%	10.4%	8.4%	9.7%	8.0%	6.8%	12.0%	8.0%	8.9%	17.7%	11.8%	8.8%	8.3%
N Science	19,539	5,525	25,064	6,033	7,269	13,301	8,399	5,502	52,266	15,382	8,594	23,975	4,896	4,794	9,691	33,666	85,932
Share of Science	22.7%	6.4%	29.2%	7.0%	8.5%	15.5%	9.8%	6.4%	60.8%	17.9%	10.0%	27.9%	5.7%	5.6%	11.3%	39.2%	100.0%
1975:																	
N Frosh.	296,216	50,744	346,960	65,929	50,835	116,764	104,904	49,607	618,235	251,343	64,153	315,496	57,676	28,876	86,552	402,048	1,020,283
% Share	29.0%	5.0%	34.0%	6.5%	5.0%	11.4%	10.3%	4.9%	60.6%	24.6%	6.3%	30.9%	5.7%	2.8%	8.5%	39.4%	100.0%
% Science	9.6%	14.8%	10.4%	9.1%	20.9%	14.3%	12.2%	14.2%	11.7%	11.5%	19.4%	13.1%	19.9%	26.3%	22.0%	15.1%	13.1%
N Science	28,554	7,526	36,080	5,993	10,648	16,641	12,850	7,064	72,634	28,983	12,464	41,447	11,465	7,603	19,068	60,515	133,149
Share of Science	21.4%	5.7%	27.1%	4.5%	8.0%	12.5%	9.7%	5.3%	54.6%	21.8%	9.4%	31.1%	8.6%	5.7%	14.3%	45.4%	100.0%

National Patterns of Enrollment, by Institutional Typology :
"Freshmen Declaring Prospective Majors in the Basic Sciences
1975, 1979 and 1984

Summary Table

Changes in Enrollments	4-Year Colleges: Public L&M Sel.	Public H Sel.	Public Total	Private Non-Sectarian L&M Sel.	Private Non-Sectarian H&VH Sl	Private Non-Sectarian Total	Priv. Sec. Prot.	Priv. Sec. Cath.	4-YR. COL. TOTAL	Universities: Public L&M Sel.	Public H Sel.	Public Total	Private L&M Sel.	Private H Sel.	Private Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
Share of All Frosh. Enrollment																	
1984	30.8%	4.3%	35.1%	8.5%	4.6%	13.1%	9.1%	4.9%	62.2%	21.7%	7.1%	28.8%	6.1%	2.9%	9.0%	37.8%	100.0%
1979	30.9%	4.7%	35.6%	7.7%	4.7%	12.3%	9.7%	5.5%	63.1%	22.0%	6.9%	28.9%	5.3%	2.6%	8.0%	36.9%	100.0%
1975	29.0%	5.0%	34.0%	6.5%	5.0%	11.4%	10.3%	4.9%	60.6%	24.6%	6.3%	30.9%	5.7%	2.8%	8.5%	39.4%	100.0%
% Change :	6.1%	-12.7%	3.3%	31.9%	-7.9%	14.6%	-11.7%	.5%	2.7%	-11.9%	12.4%	-7.0%	8.5%	1.9%	6.3%	-4.1%	.0
% of Frosh with Science as Major																	
1984	6.0%	10.8%	6.6%	5.7%	14.0%	8.6%	7.9%	7.6%	7.3%	6.9%	12.5%	8.2%	9.6%	17.4%	12.1%	9.2%	8.0%
1979	6.1%	11.4%	6.8%	7.6%	15.1%	10.4%	8.4%	9.7%	8.0%	6.8%	12.0%	8.0%	8.9%	17.7%	11.8%	8.8%	8.3%
1975	9.6%	14.8%	10.4%	9.1%	20.9%	14.3%	12.2%	14.2%	11.7%	11.5%	19.4%	13.1%	19.9%	26.3%	22.0%	15.1%	13.1%
% Change :	-37.8%	-27.2%	-36.6%	-37.5%	-33.2%	-39.8%	-35.5%	-46.6%	-38.0%	-40.4%	-35.9%	-37.2%	-51.7%	-33.9%	-45.1%	-39.1%	-38.7%
Share of Science Market																	
1984	23.1%	5.9%	29.0%	6.1%	8.0%	14.1%	9.0%	4.6%	56.7%	18.7%	11.0%	29.7%	7.4%	6.3%	13.6%	43.3%	100.0%
1979	22.7%	6.4%	29.2%	7.0%	8.5%	15.5%	9.8%	6.4%	60.8%	17.9%	10.0%	27.9%	5.7%	5.6%	11.3%	39.2%	100.0%
1975	21.4%	5.7%	27.1%	4.5%	8.0%	12.5%	9.7%	5.3%	54.6%	21.8%	9.4%	31.1%	8.6%	5.7%	14.3%	45.4%	100.0%
% Change :	7.8%	3.7%	7.0%	34.6%	.4%	12.7%	-7.0%	-12.4%	3.9%	-14.3%	17.6%	-4.7%	-14.4%	9.8%	-4.7%	-4.7%	.0

Sources: "The American Freshman: National Norms for Fall, 1984"
Astin, Green, Korn and Maier, American Council on Education, 1984
"The American Freshman: National Norms for Fall, 1979"
Astin, King and Richardson, American Council on Education, 1979
"The American Freshman: National Norms for Fall, 1975"
Astin, King, Light and Richardson, American Council on Education, 1975

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National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in the Biological Sciences
1975, 1979 and 1984

	2-Year Colleges			4-Year Colleges									Universities							
				Public			Private Non-Sectarian			Priv. Sec.			Public			Private				
	Public	Priv.	2-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.	4-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
1984:																				
N Frosh.	531,939	74,751	606,690	316,797	44,643	361,440	37,687	47,221	134,908	93,430	50,270	640,048	223,104	72,663	295,767	63,063	29,653	92,716	388,483	1,635,221
% Share	32.5%	4.6%	37.1%	19.4%	2.7%	22.1%	5.4%	2.9%	8.3%	5.7%	3.1%	39.1%	13.6%	4.4%	18.1%	3.9%	1.8%	5.7%	23.8%	100.0%
% Bio Sci	2.7%	2.8%	2.7%	3.6%	3.7%	3.6%	3.6%	8.5%	5.3%	5.1%	4.5%	4.2%	4.2%	7.3%	5.0%	6.3%	9.9%	7.4%	5.5%	4.0%
N Bio Sci	14,362	2,093	16,455	11,279	1,652	12,931	3,192	4,021	7,213	4,765	2,262	27,170	9,346	5,300	14,645	3,950	2,931	6,881	21,526	65,152
Share of Bio. Sci.	22.0%	3.2%	25.3%	17.3%	2.5%	19.8%	4.9%	6.2%	11.1%	7.3%	3.5%	41.7%	14.3%	8.1%	22.5%	6.1%	4.5%	10.6%	33.0%	100.0%
1979:																				
N Frosh.	619,918	60,850	680,768	319,253	48,274	367,527	79,336	48,052	127,388	99,992	56,719	651,626	226,960	71,536	298,496	55,131	27,123	82,254	380,750	1,713,144
% Share	36.2%	3.6%	39.7%	18.6%	2.8%	21.5%	4.6%	2.8%	7.4%	5.8%	3.3%	38.0%	13.2%	4.2%	17.4%	3.2%	1.6%	4.8%	22.2%	100.0%
% Bio Sci	2.8%	1.9%	2.7%	3.6%	4.0%	3.7%	5.0%	8.8%	6.5%	4.9%	6.6%	4.7%	3.8%	6.7%	4.5%	5.4%	9.1%	6.6%	5.0%	4.0%
N Bio Sci	17,358	1,156	18,514	11,509	1,931	13,440	3,987	4,239	8,225	4,900	3,743	30,309	8,676	4,824	13,500	2,980	2,473	5,452	18,953	67,775
Share of Bio. Sci.	25.6%	1.7%	27.3%	17.0%	2.8%	19.8%	5.9%	6.3%	12.1%	7.2%	5.5%	44.7%	12.8%	7.1%	19.9%	4.4%	3.6%	8.0%	28.0%	100.0%
1975:																				
N Frosh.	687,029	53,218	740,247	296,216	50,744	346,960	65,929	50,835	116,764	104,904	49,607	618,235	251,343	64,153	315,496	57,676	28,876	86,552	402,048	1,760,530
% Share	39.0%	3.0%	42.0%	16.8%	2.9%	19.7%	3.7%	2.9%	6.6%	6.0%	2.8%	35.1%	14.3%	3.6%	17.9%	3.3%	1.6%	4.9%	22.8%	100.0%
% Bio Sci	3.7%	2.7%	3.7%	5.8%	5.1%	5.7%	6.2%	13.2%	9.3%	7.7%	10.4%	7.1%	7.3%	12.3%	8.4%	12.9%	15.4%	13.7%	9.5%	6.2%
N Bio Sci	25,757	1,463	27,220	17,068	2,613	19,681	4,119	6,732	10,851	8,129	5,179	43,840	18,427	7,922	26,350	7,415	4,450	11,865	38,215	109,274
Share of Bio. Sci.	23.6%	1.3%	24.9%	15.6%	2.4%	18.0%	3.8%	6.2%	9.9%	7.4%	4.7%	40.1%	16.9%	7.2%	24.1%	6.8%	4.1%	10.9%	35.0%	100.0%

National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in the Biological Sciences
1975, 1979 and 1984

Summary Table

Change in Bio. Sci.	2-Year Colleges			4 - Year Colleges									Universities							
				Public			Private Non-Sectarian			Priv. Sec.			Public			Private				
	Public	Priv.	2-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.	4-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
% of Fresh with Bio. as Major																				
1984	2.7%	2.8%	2.7%	3.6%	5.7%	3.6%	3.6%	8.5%	5.3%	5.1%	4.5%	4.2%	4.2%	7.3%	5.0%	6.3%	9.9%	7.4%	5.5%	4.0%
1979	2.8%	1.9%	2.7%	3.6%	4.0%	3.7%	5.0%	8.8%	6.5%	4.9%	6.6%	4.7%	3.8%	6.7%	4.5%	5.4%	9.1%	6.6%	5.0%	4.0%
1975	3.7%	2.5%	3.7%	5.0%	5.1%	5.7%	6.2%	13.2%	9.3%	7.7%	10.4%	7.1%	7.3%	12.3%	8.4%	12.9%	15.4%	13.7%	9.5%	6.2%
% Change :	-28.0%	1.9%	-26.2%	-38.2%	-28.1%	-36.9%	-41.7%	-35.7%	-42.5%	-34.2%	-56.9%	-40.1%	-42.9%	-40.9%	-40.7%	-51.3%	-35.9%	-45.9%	-41.7%	-35.8%
Share of Bio. Market																				
1984	22.0%	3.2%	25.3%	17.3%	2.5%	19.8%	4.9%	6.2%	11.1%	7.3%	3.5%	41.7%	14.3%	8.1%	22.5%	6.1%	4.5%	10.6%	33.0%	100.0%
1979	25.6%	1.7%	27.3%	17.0%	2.8%	19.8%	5.9%	6.3%	12.1%	7.2%	5.5%	44.7%	12.8%	7.1%	19.9%	4.4%	3.6%	8.0%	28.0%	100.0%
1975	23.6%	1.3%	24.9%	15.6%	2.4%	18.0%	3.8%	6.2%	9.9%	7.4%	4.7%	40.1%	16.9%	7.2%	24.1%	6.8%	4.1%	10.9%	35.0%	100.0%
% Change :	-6.5%	140.0%	1.4%	10.8%	6.0%	10.2%	30.0%	.2%	11.5%	-1.7%	-26.7%	3.9%	-14.9%	12.2%	-6.8%	-10.6%	10.5%	-2.7%	-5.5%	.0

Sources: "The American Freshman: National Norms for Fall, 1984"
Astin, Green, Korn and Maier, American Council on Education, 1984
"The American Freshman: National Norms for Fall, 1979"
Astin, King and Richardson, American Council on Education, 1979
"The American Freshman: National Norms for Fall, 1975"
Astin, King, and Richardson, American Council on Education, 1975

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National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in Physical Sciences & Mathematics
1975, 1979 and 1984

	2-Year Colleges			4-Year Colleges									Universities							
				Public			Private Non-Sectarian			Priv. Sec.			Public			Private				
	Public	Priv.	2-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.	4-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
1984:																				
N Frosh.	531,939	74,751	606,690	316,797	44,643	361,440	87,687	47,221	134,908	93,430	50,270	640,048	223,104	72,663	295,767	63,063	29,653	92,716	388,483	1,635,221
% Share	32.5%	4.6%	37.1%	19.4%	2.7%	22.1%	5.4%	2.9%	8.3%	5.7%	3.1%	39.1%	13.6%	4.4%	18.1%	3.9%	1.8%	5.7%	23.8%	100.0%
% P. Sci.	1.7%	1.0%	1.6%	2.4%	7.1%	3.0%	2.0%	5.5%	3.2%	2.8%	3.1%	3.0%	2.7%	5.2%	3.3%	3.3%	7.5%	4.7%	3.6%	2.6%
N P. Sci.	9,043	777	9,820	7,729	3,170	10,899	1,799	2,582	4,370	2,616	1,558	19,443	5,971	3,748	9,719	2,098	2,226	4,324	14,044	43,308
Share of Physical Sci	20.9%	1.8%	22.7%	17.8%	7.3%	25.2%	4.1%	6.0%	10.1%	6.0%	3.6%	44.9%	13.8%	8.7%	22.4%	4.8%	5.1%	10.0%	32.4%	100.0%
1979:																				
N Frosh.	619,918	60,850	680,768	319,253	48,274	367,527	79,336	48,052	127,388	99,992	56,719	651,626	226,960	71,536	298,496	55,131	27,123	82,254	380,750	1,713,144
% Share	36.2%	3.6%	39.7%	18.6%	2.8%	21.5%	4.6%	2.8%	7.4%	5.8%	3.3%	38.0%	13.2%	4.2%	17.4%	3.2%	1.6%	4.8%	22.2%	100.0%
% P. Sci.	1.8%	1.3%	1.8%	2.5%	7.4%	3.2%	2.6%	6.3%	4.0%	3.5%	3.1%	3.4%	3.0%	5.3%	3.5%	3.5%	8.6%	5.2%	3.9%	2.8%
N P. Sci.	11,159	791	11,950	8,029	3,584	11,614	2,046	3,030	5,076	3,500	1,798	21,948	6,705	3,770	10,475	1,917	2,322	4,238	14,713	48,611
Share of Physical Sci	23.0%	1.6%	24.6%	16.5%	7.4%	23.9%	4.2%	6.2%	10.4%	7.2%	3.6%	45.2%	13.8%	7.8%	21.5%	3.9%	4.8%	8.7%	30.3%	100.0%
1975:																				
N Frosh.	687,029	53,218	740,247	296,216	50,744	346,960	65,929	50,835	116,764	104,904	49,607	618,235	251,343	64,153	315,496	57,676	28,876	86,552	402,048	1,760,530
% Share	39.0%	3.0%	42.0%	16.8%	2.9%	19.7%	3.7%	2.9%	6.6%	6.0%	2.8%	35.1%	14.3%	3.6%	17.9%	3.3%	1.6%	4.9%	22.8%	100.0%
% P. Sci.	2.0%	1.4%	1.9%	3.9%	9.7%	4.7%	2.8%	7.7%	5.0%	4.5%	3.8%	4.7%	4.2%	7.1%	4.8%	7.0%	10.9%	8.3%	5.5%	3.7%
N P. Sci.	13,617	735	14,352	11,486	4,913	16,399	1,874	3,915	5,790	4,721	1,885	28,794	10,556	4,542	15,097	4,050	3,153	7,203	22,300	65,447
Share of Physical Sci	20.8%	1.1%	21.9%	17.6%	7.5%	25.1%	2.9%	6.0%	8.8%	7.2%	2.9%	44.0%	16.1%	6.9%	23.1%	6.2%	4.8%	11.0%	34.1%	100.0%

National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in Physical Sciences & Mathematics
1975, 1979 and 1984

Summary Table

Change in Physical Sci	2-Year Colleges			4-Year Colleges								Universities							
				Public			Private Non-Sectarian			Priv. Sec.			Public			Private			
	Public	Priv.	2-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.	4-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
% of Frosh with P. Sci. as Major																			
1984	1.7%	1.0%	1.6%	2.4%	7.1%	3.0%	2.0%	5.5%	3.2%	2.8%	3.1%	3.0%	2.7%	5.2%	3.3%	3.3%	7.5%	4.7%	3.6%	2.6%
1979	1.8%	1.3%	1.8%	2.5%	7.4%	3.2%	2.6%	6.3%	4.0%	3.5%	3.1%	3.4%	3.0%	5.3%	3.5%	3.5%	8.6%	5.2%	3.9%	2.8%
1975	2.0%	1.4%	1.9%	3.9%	9.7%	4.7%	2.8%	7.7%	5.0%	4.5%	3.8%	4.7%	4.2%	7.1%	4.8%	7.0%	10.9%	8.3%	5.5%	3.7%
% Change :	-14.2%	-24.7%	-16.5%	-37.1%	-26.7%	-36.2%	-28.2%	-29.0%	-34.7%	-37.8%	-18.4%	-34.8%	-36.3%	-27.1%	-31.3%	-52.6%	-31.2%	-44.0%	-34.8%	-28.8%
Share of P. Sci. Market																			
1984	20.9%	1.8%	22.7%	17.8%	7.3%	25.2%	4.1%	6.0%	10.1%	6.0%	3.6%	44.9%	13.8%	8.7%	22.4%	4.8%	5.1%	10.0%	32.4%	100.0%
1979	23.0%	1.6%	24.6%	16.5%	7.4%	23.9%	4.2%	6.2%	10.4%	7.2%	3.6%	45.2%	13.8%	7.8%	21.5%	3.9%	4.8%	8.7%	30.3%	100.0%
1975	20.8%	1.1%	21.9%	17.6%	7.5%	25.1%	2.9%	6.0%	8.8%	7.4%	2.9%	44.0%	16.1%	6.9%	23.1%	6.2%	4.8%	11.0%	34.1%	100.0%
% Change :	.4%	59.7%	3.4%	1.7%	-2.5%	.4%	44.2%	-.4%	14.1%	-16.3%	24.9%	2.0%	-14.5%	24.7%	-2.7%	-21.7%	6.7%	-9.3%	-4.8%	.0

Sources: "The American Freshman: National Norms for Fall, 1984"
Astin, Green, Korn and Maier, American Council on Education, 1984
"The American Freshman: National Norms for Fall, 1979"
Astin, King and Richardson, American Council on Education, 1979
"The American Freshman: National Norms for Fall, 1975"
Astin, King, and Richardson, American Council on Education, 1975

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National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in Chemistry,
1975, 1979 and 1984

	2-Year Colleges			4-Year Colleges									Universities							
				Public			Private Non-Sectarian			Priv. Sec.			Public			Private				
	Public	Priv.	2-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.	4-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
1984:																				
N Frosh.	531,939	74,751	606,690	316,797	44,643	361,440	87,607	47,221	134,908	93,430	50,270	640,048	223,104	72,663	295,767	63,063	29,653	92,716	388,483	1,635,221
% Share	32.5%	4.6%	37.1%	19.4%	2.7%	22.1%	5.4%	2.9%	8.3%	5.7%	3.1%	39.1%	13.6%	4.4%	18.1%	3.9%	1.8%	5.7%	23.8%	100.0%
% Chem.	.5%	.2%	.4%	.6%	1.6%	.8%	.6%	1.9%	1.1%	1.1%	1.0%	.9%	.8%	1.8%	1.0%	1.6%	2.0%	1.7%	1.2%	.8%
N Chem.	2,527	150	2,676	2,018	714	2,732	563	914	1,476	1,028	503	5,739	1,732	1,274	3,006	1,017	598	1,616	4,621	13,037
Share of Chemistry	19.4%	1.1%	20.5%	15.5%	5.5%	21.0%	4.3%	7.0%	11.3%	7.9%	3.9%	44.0%	13.3%	9.8%	23.1%	7.8%	4.6%	12.4%	35.4%	100.0%
1979:																				
N Frosh.	619,918	60,850	680,768	319,253	48,274	367,527	79,336	48,052	127,388	99,992	56,719	651,626	226,960	71,536	298,496	55,131	27,123	82,254	380,750	1,713,144
% Share	36.2%	3.6%	39.7%	18.6%	2.8%	21.5%	4.6%	2.8%	7.4%	5.8%	3.3%	38.0%	13.2%	4.2%	17.4%	3.2%	1.6%	4.8%	22.2%	100.0%
% Chem.	.4%	.2%	.4%	.6%	1.5%	.7%	.7%	2.3%	1.3%	1.4%	1.3%	1.0%	.9%	2.1%	1.2%	1.2%	2.9%	1.8%	1.3%	.8%
N Chem.	2,480	122	2,601	1,932	724	2,656	555	1,088	1,643	1,400	737	6,436	2,094	1,508	3,603	668	776	1,444	5,046	14,084
Share of Chemistry	17.6%	.9%	18.5%	13.7%	5.1%	18.9%	3.9%	7.7%	11.7%	9.9%	5.2%	45.7%	14.9%	10.7%	25.6%	4.7%	5.5%	10.3%	35.8%	100.0%
1975																				
N Frosh.	687,029	53,218	740,247	296,216	50,744	346,960	65,929	50,835	116,764	104,904	49,607	618,235	251,343	64,153	315,496	57,676	28,876	86,552	402,048	1,760,530
% Share	39.0%	3.0%	42.0%	16.8%	2.9%	19.7%	3.7%	2.9%	6.6%	6.0%	2.8%	35.1%	14.3%	3.6%	17.9%	3.3%	1.6%	4.9%	22.8%	100.0%
% Chem.	.6%	.2%	.6%	1.0%	1.7%	1.1%	1.0%	2.7%	1.7%	2.1%	1.4%	1.4%	1.4%	2.0%	1.5%	3.2%	3.5%	3.3%	1.9%	1.2%
N Chem.	4,383	110	4,492	2,829	870	3,699	642	1,394	2,036	2,155	684	8,573	3,451	1,303	4,753	1,850	1,023	2,873	7,636	20,692
Share of Chemistry	21.2%	.5%	21.7%	13.7%	4.2%	17.9%	3.1%	6.7%	9.8%	10.4%	3.3%	41.4%	16.7%	6.3%	23.0%	8.9%	4.9%	13.9%	36.9%	100.0%

National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in Chemistry,
1975, 1979 and 1984

Summary Table

Change in Chemistry	2-Year Colleges			4 - Y e a r C o l l e g e s									U n i v e r s i t i e s							
				Public			Private Non-Sectarian			Priv. Sec.		4-YR.	Public			Private				
	Public	Priv.	2-YR. COL. TOTAL	LAN Sel.	H Sel.	Total	LAN Sel.	HAVH SI	Total	Prot.	Cath.	COL. TOTAL	LAN Sel.	H Sel.	Total	LAN Sel.	H Sel.	Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
% of Frosh with Chem. as Major																				
1984	.5%	.2%	.4%	.6%	1.6%	.8%	.6%	1.9%	1.1%	1.1%	1.0%	.9%	.8%	1.8%	1.0%	1.6%	2.0%	1.7%	1.2%	.8%
1979	.4%	.2%	.4%	.6%	1.5%	.7%	.7%	2.3%	1.3%	1.4%	1.3%	1.0%	.9%	2.1%	1.2%	1.2%	2.9%	1.8%	1.3%	.9%
1975	.6%	.2%	.6%	1.0%	1.7%	1.1%	1.0%	2.7%	1.7%	2.1%	1.4%	1.4%	1.4%	2.0%	1.5%	3.2%	3.5%	3.3%	1.9%	1.2%
% Change :	-25.5%	-2.8%	-27.3%	-33.3%	-6.6%	-29.1%	-34.1%	-29.4%	-37.2%	-46.4%	-27.5%	-35.3%	-43.5%	-13.7%	-32.5%	-49.7%	-43.0%	-47.5%	-37.3%	-32.2%
Share of Chem. Market																				
1984	19.4%	1.1%	20.5%	15.5%	5.5%	21.5%	4.3%	7.0%	11.3%	7.9%	3.9%	44.0%	13.3%	9.8%	23.1%	7.8%	4.6%	12.4%	35.4%	100.0%
1979	17.6%	.9%	18.5%	13.7%	5.1%	18.9%	3.9%	7.7%	11.7%	9.9%	5.2%	45.7%	14.9%	10.7%	25.6%	4.7%	5.5%	10.3%	35.8%	100.0%
1975	21.2%	.5%	21.7%	13.7%	4.2%	17.9%	3.1%	6.7%	9.8%	10.4%	3.3%	41.4%	16.7%	6.3%	23.0%	8.9%	4.9%	13.9%	36.9%	100.0%
% Change :	-8.5%	116.6%	-5.4%	13.2%	30.4%	17.2%	39.1%	4.1%	15.1%	-24.3%	16.7%	6.3%	-20.3%	55.2%	.4%	-12.7%	-7.2%	-10.7%	-3.8%	.0

Sources: "The American Freshman: National Norms for Fall, 1984"
Astin, Green, Korn and Maier, American Council on Education, 1984
"The American Freshman: National Norms for Fall, 1979"
Astin, King and Richardson, American Council on Education, 1979
"The American Freshman: National Norms for Fall, 1975"
Astin, King, and Richardson, American Council on Education, 1975

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National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in "Earth Sciences",
1975, 1979 and 1984

	2-Year Colleges			4 - Y e a r C o l l e g e s									U n i v e r s i t i e s							
				Public			Private Non-Sectarian			Priv. Sec.			Public			Private				
	Public	Priv.	2-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.	4-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
1984:																				
N Frosh.	531,939	74,751	606,690	316,797	44,643	361,440	87,687	47,221	134,908	93,430	50,270	640,048	223,104	72,663	295,767	63,063	29,653	92,716	388,483	1,635,221
% Share	32.5%	4.6%	37.1%	19.4%	2.7%	22.1%	5.4%	2.9%	8.3%	5.7%	3.1%	39.1%	13.6%	4.4%	18.1%	3.9%	1.8%	5.7%	23.8%	100.0%
% E. Sci.	.2%	.0	.2%	.2%	.1%	.2%	.0	.2%	.1%	.1%	.1%	.2%	.2%	.2%	.2%	.1%	.2%	.1%	.2%	.2%
N E. Sci.	1,064	22	1,086	742	45	787	41	94	135	93	50	1,065	400	146	546	39	47	86	632	2,784
Share of Earth Sci.	38.2%	.8%	39.0%	26.7%	1.6%	28.3%	1.5%	3.4%	4.8%	3.3%	1.8%	38.3%	14.4%	5.2%	19.6%	1.4%	1.7%	3.1%	22.7%	100.0%
1979:																				
N Frosh.	619,918	60,850	680,768	319,253	48,274	367,527	79,336	48,052	127,388	99,992	56,719	651,626	226,960	71,536	298,496	55,131	27,123	82,254	380,750	1,713,144
% Share	36.2%	3.6%	39.7%	18.6%	2.8%	21.5%	4.6%	2.8%	7.4%	5.8%	3.3%	38.0%	13.2%	4.2%	17.4%	3.2%	1.6%	4.8%	22.2%	100.0%
% E. Sci.	.3%	.1%	.3%	.3%	.3%	.3%	.2%	.5%	.3%	.4%	.1%	.3%	.3%	.5%	.3%	.2%	.4%	.2%	.3%	.3%
N E. Sci.	1,860	61	1,921	1,070	145	1,214	172	242	414	400	57	2,085	667	323	991	84	96	180	1,171	5,177
Share of Earth Sci.	35.9%	1.2%	37.1%	20.7%	2.8%	23.5%	3.3%	4.7%	8.0%	7.7%	1.1%	40.3%	12.9%	6.2%	19.1%	1.6%	1.9%	3.5%	22.6%	100.0%
1975																				
N Frosh.	687,029	53,218	740,247	296,216	50,744	346,960	65,929	50,835	116,764	104,904	49,607	618,235	251,343	64,153	315,496	57,676	28,876	86,552	402,048	1,760,530
% Share	39.0%	3.0%	42.0%	16.8%	2.9%	19.7%	3.7%	2.9%	6.6%	6.0%	2.8%	35.1%	14.3%	3.6%	17.9%	3.3%	1.6%	4.9%	22.8%	100.0%
% E. Sci.	.2%	.1%	.2%	.4%	.5%	.4%	.2%	.5%	.3%	.2%	.1%	.3%	.4%	.4%	.4%	.2%	.3%	.3%	.4%	.3%
N E. Sci.	1,117	50	1,167	1,109	265	1,375	133	246	379	187	39	1,980	1,019	268	1,279	139	80	219	1,498	4,645
Share of Earth Sci.	24.0%	1.1%	25.1%	23.9%	5.7%	29.6%	2.9%	5.3%	8.2%	4.0%	.8%	42.6%	21.8%	5.8%	27.5%	3.0%	1.7%	4.7%	32.3%	100.0%

National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in "Earth Sciences",
1975, 1979 and 1984

Summary Table

Change in Earth Sci.	2-Year Colleges			4-Year Colleges									Universities							
				Public			Private Non-Sectarian			Priv. Sec.		4-Yr. Col.	Public			Private			Univ.	National Grand
	Public	Priv.	2-Yr. Col. Total	Lib Sel.	H Sel.	Total	Lib Sel.	H&VH Sl	Total	Prot.	Cath.	Total	Lib Sel.	H Sel.	Total	Lib Sel.	H Sel.	Total	Total	Total
% of Frosh with E. Sci. as Major																				
1984	.2%	.0	.2%	.2%	.1%	.2%	.0	.2%	.1%	.1%	.1%	.2%	.2%	.2%	.2%	.1%	.2%	.1%	.2%	.2%
1979	.3%	.1%	.3%	.3%	.3%	.3%	.2%	.5%	.3%	.4%	.1%	.3%	.3%	.5%	.3%	.2%	.4%	.2%	.3%	.3%
1975	.2%	.1%	.2%	.4%	.5%	.4%	.2%	.5%	.3%	.2%	.1%	.3%	.4%	.4%	.4%	.2%	.3%	.3%	.4%	.3%
% Change :	33.1%	-48.4%	13.6%	-37.5%	-80.9%	-45.1%	-77.1%	-58.7%	-69.2%	-43.8%	25.7%	-48.0%	-55.4%	-52.0%	-54.5%	-74.3%	-42.7%	-63.2%	-56.3%	-35.5%
Share of E. Sci. Market																				
1984	38.2%	.8%	39.0%	26.7%	1.6%	28.3%	1.5%	3.4%	4.8%	3.4%	1.8%	38.3%	14.4%	5.2%	19.6%	1.4%	1.7%	3.1%	22.7%	100.0%
1979	35.9%	1.2%	37.1%	20.7%	2.8%	23.5%	3.3%	4.7%	8.0%	7.7%	1.1%	40.3%	12.9%	6.2%	19.1%	1.6%	1.9%	3.5%	22.6%	100.0%
1975	24.0%	1.1%	25.1%	23.9%	5.7%	29.6%	2.9%	5.3%	8.2%	4.0%	.8%	42.6%	21.8%	5.8%	27.5%	3.0%	1.7%	4.7%	32.3%	100.0%
% Change :	59.0%	-25.9%	55.3%	11.6%	-71.9%	-4.5%	-49.1%	-36.0%	-40.6%	-16.4%	112.6%	-10.2%	-34.0%	-9.2%	-28.8%	-53.1%	-1.8%	-34.3%	-29.6%	.0

Sources: "The American Freshman: National Norms for Fall, 1984"
Astin, Green, Korn and Maier, American Council on Education, 1984
"The American Freshman: National Norms for Fall, 1979"
Astin, King and Richardson, American Council on Education, 1979
"The American Freshman: National Norms for Fall, 1975"
Astin, King, and Richardson, American Council on Education, 1975

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National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in "Mathematics & Statistics"
1975, 1979 and 1984

	2-Year Colleges			4-Year Colleges									Universities							
				Public			Private Non-Sectarian			Priv. Sec.		4-YR. COL. TOTAL	Public			Private			UNIV. TOTAL	NATIONAL GRAND TOTAL
	Public	Priv.	2-YR. COL. TOTAL	LAM Sel.	H Sel.	Total	LAM Sel.	HAVH SI	Total	Prot.	Cath.		LAM Sel.	H Sel.	Total	LAM Sel.	N Sel.	Total		
1984:																				
N Frosh.	531,939	74,751	606,690	316,797	44,643	361,440	87,687	47,221	134,908	93,430	50,270	640,048	223,104	72,663	295,767	63,063	29,653	92,716	388,483	1,635,221
% Share	32.5%	4.6%	37.1%	19.4%	2.7%	22.1%	5.4%	2.9%	8.3%	5.7%	3.1%	39.1%	13.6%	4.4%	18.1%	3.9%	1.8%	5.7%	23.8%	100.0%
% Math.	.4%	.2%	.4%	.9%	2.4%	1.1%	.8%	1.6%	1.1%	1.1%	1.3%	1.1%	.9%	1.7%	1.1%	.8%	2.1%	1.2%	1.1%	.8%
N Math.	2,128	150	2,277	2,960	1,071	4,031	713	739	1,453	1,028	654	7,165	2,000	1,216	3,216	504	628	1,133	4,439	13,871
Share of Mathematics	15.3%	1.1%	16.4%	21.3%	7.7%	29.1%	5.1%	5.3%	10.5%	7.4%	4.7%	51.7%	15.2%	8.8%	23.8%	3.6%	4.5%	8.2%	31.9%	100.0%
1979:																				
N Frosh.	619,918	60,850	680,768	319,253	48,274	367,527	79,336	48,052	127,388	99,992	56,719	651,626	228,960	71,536	298,496	55,131	27,123	82,254	380,750	1,713,144
% Share	36.2%	3.6%	39.7%	18.6%	2.8%	21.5%	4.6%	2.8%	7.4%	5.8%	3.3%	38.0%	13.2%	4.2%	17.4%	3.2%	1.6%	4.8%	22.2%	100.0%
% Math.	.2%	.4%	.3%	.6%	1.7%	.8%	.6%	1.7%	1.0%	1.0%	1.1%	.9%	.6%	1.5%	.8%	.8%	1.7%	1.1%	.9%	.6%
N Math.	1,488	243	1,731	2,027	821	2,848	489	823	1,312	1,000	624	5,784	1,379	1,073	2,452	467	474	940	3,393	10,907
Share of Mathematics	13.6%	2.2%	15.9%	18.6%	7.5%	26.1%	4.5%	7.5%	12.0%	9.2%	5.7%	53.0%	12.6%	9.8%	22.5%	4.3%	4.3%	8.6%	31.1%	100.0%
1975																				
N Frosh.	687,029	53,218	740,247	296,216	50,744	346,960	65,929	50,835	116,764	104,904	49,607	618,235	251,343	64,153	315,496	57,676	28,876	86,552	402,048	1,760,530
% Share	39.0%	3.0%	42.0%	16.8%	2.9%	19.7%	3.7%	2.9%	6.6%	6.0%	2.8%	35.1%	14.3%	3.6%	17.9%	3.3%	1.6%	4.9%	22.8%	100.0%
% Math.	.4%	.5%	.4%	1.2%	3.3%	1.5%	.9%	2.3%	1.5%	1.5%	1.5%	1.5%	1.3%	2.1%	1.4%	1.8%	3.1%	2.2%	1.6%	1.1%
N Math.	2,935	254	3,188	3,409	1,696	5,107	585	1,138	1,713	1,560	746	9,126	3,158	1,317	4,475	1,032	883	1,915	6,390	18,705
Share of Mathematics	15.7%	1.4%	17.0%	18.2%	9.1%	27.3%	3.1%	6.0%	9.2%	8.3%	4.0%	48.8%	16.9%	7.0%	23.9%	5.5%	4.7%	10.2%	34.2%	100.0%

National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in "Mathematics & Statistics"
1975, 1979 and 1984

Summary Table

Change in Mathematics	2-Year Colleges			4-Year Colleges									Universities						NATIONAL GRAND TOTAL
				Public			Private Non-Sectarian			Priv. Sec.		4-YR. COL. TOTAL	Public			Private			UNIV. TOTAL	
	Public	Priv.	2-YR. COL. TOTAL	LAM Sel.	H Sel.	Total	LAM Sel.	HAVH El	Total	Prot.	Cath.		LAM Sel.	H Sel.	Total	LAM Sel.	H Sel.	Total		
% of Frsh with Math. as Major																			
1984	.4%	.3%	.4%	.9%	2.4%	1.1%	.8%	1.6%	1.1%	1.1%	1.3%	1.1%	.9%	1.7%	1.1%	.8%	2.1%	1.2%	1.1%	.8%
1979	.2%	.4%	.3%	.6%	1.7%	.8%	.6%	1.7%	1.0%	1.0%	1.1%	.9%	.6%	1.5%	.8%	.8%	1.7%	1.1%	.9%	.6%
1975	.4%	.5%	.4%	1.2%	3.3%	1.5%	.9%	2.2%	1.5%	1.5%	1.5%	1.5%	1.3%	2.1%	1.4%	1.8%	3.1%	2.2%	1.6%	1.1%
% Change :	-6.4%	-58.0%	-12.8%	-18.8%	-28.3%	-24.2%	-8.4%	-29.4	-26.6%	-26.0%	-13.6%	-24.2%	-25.8%	-18.5%	-21.4%	-55.3%	-30.7%	-44.8%	-28.3%	-20.2%
Share of Math. Market																			
1984	15.3%	1.1%	16.4%	21.3%	7.7%	29.1%	5.1%	5.3%	10.5%	7.4%	4.7%	51.7%	15.0%	8.0%	23.0%	3.6%	4.5%	8.2%	31.9%	100.0%
1979	13.6%	2.2%	15.9%	18.6%	7.5%	26.1%	4.5%	7.5%	12.0%	9.2%	5.7%	53.0%	12.6%	9.0%	22.5%	4.3%	4.3%	8.6%	31.1%	100.0%
1975	15.7%	1.4%	17.0%	18.2%	9.1%	27.3%	3.1%	6.0%	9.2%	8.3%	4.0%	48.8%	16.9%	7.0%	23.9%	5.5%	4.7%	10.2%	34.2%	100.0%
% Change :	-2.2%	-20.5%	-3.7%	17.1%	-14.9%	6.4%	64.4%	-11.6%	14.3%	-11.2%	18.1%	5.9%	-11.2%	24.5%	-.7%	-34.1%	-4.0%	-20.2%	-6.5%	.0

Sources: "The American Freshman: National Norms for Fall, 1984"
Astin, Green, Korn and Maier, American Council on Education, 1984
"The American Freshman: National Norms for Fall, 1979"
Astin, King and Richardson, American Council on Education, 1979
"The American Freshman: National Norms for Fall, 1975"
Astin, King, and Richardson, American Council on Education, 1975

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National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in Physics (and Astronomy)
1975, 1979 and 1984

	2-Year Colleges			4 - Y e a r C o l l e g e s									U n i v e r s i t i e s							
				Public			Private Non-Sectarian			Priv. Sec.			Public			Private				
	Public	Priv.	2-YR. COL. TOTAL	L&H Sel.	H Sel.	Total	L&H Sel.	H&WH Sl	Total	Prot.	Cath.	4-YR. COL. TOTAL	L&H Sel.	H Sel.	Total	L&H Sel.	H Sel.	Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
1 9 8 4:																				
N Frosh.	531,939	74,751	606,690	316,797	44,643	361,440	87,687	47,221	134,908	93,430	50,270	640,048	223,104	72,663	295,767	63,063	29,653	92,716	388,483	1,635,221
% Share	32.5%	4.6%	37.1%	19.4%	2.7%	22.1%	5.4%	2.9%	8.3%	5.7%	3.1%	39.1%	13.6%	4.4%	18.1%	3.9%	1.8%	5.7%	23.8%	100.0%
% Phys.	.3%	.2%	.3%	.3%	1.9%	.5%	.3%	1.4%	.7%	.4%	.5%	.5%	.4%	1.1%	.6%	.6%	2.9%	1.3%	.7%	.5%
N Phys.	1,596	150	1,745	830	848	1,678	225	666	891	374	251	3,194	883	785	1,668	385	856	1,241	2,909	7,848
Share of Phys. & Ast.	20.3%	1.9%	22.2%	10.6%	10.8%	21.4%	2.9%	8.5%	11.3%	4.8%	3.2%	40.7%	11.2%	10.0%	21.3%	4.9%	10.9%	15.8%	37.1%	100.0%
1 9 7 9:																				
N Frosh.	619,918	60,850	680,768	319,253	48,274	367,527	79,136	48,052	127,388	99,992	56,719	651,626	226,960	71,536	298,496	55,131	27,123	82,254	380,750	1,713,144
% Share	36.2%	3.6%	39.7%	18.6%	2.8%	21.5%	4.6%	2.8%	7.4%	5.8%	3.3%	38.0%	13.2%	4.2%	17.4%	3.2%	1.6%	4.8%	22.2%	100.0%
% Phys.	.3%	.2%	.3%	.4%	1.8%	.6%	.3%	1.4%	.8%	.5%	.3%	.6%	.5%	.8%	.6%	.9%	3.2%	1.7%	.8%	.5%
N Phys.	1,860	122	1,981	1,277	869	2,146	271	685	956	500	170	3,773	1,123	577	1,701	506	857	1,364	3,064	8,818
Share of Phys. & Ast.	21.1%	1.4%	22.5%	14.5%	9.9%	24.3%	3.1%	7.8%	10.8%	5.7%	1.9%	42.8%	12.7%	6.5%	19.3%	5.7%	9.7%	15.5%	34.8%	100.0%
1 9 7 5																				
N Frosh.	687,029	53,218	740,247	286,216	50,744	346,960	65,929	50,835	116,764	104,904	49,607	618,235	251,343	64,153	315,496	57,676	28,876	86,552	402,048	1,760,530
% Share	39.0%	3.0%	42.0%	16.8%	2.9%	19.7%	3.7%	2.9%	6.6%	6.0%	2.8%	35.1%	14.3%	3.6%	17.9%	3.3%	1.6%	4.9%	22.8%	100.0%
% Phys.	.2%	.1%	.2%	.5%	1.7%	.7%	.3%	1.6%	.8%	.8%	.5%	.7%	.6%	1.7%	.8%	1.1%	3.4%	1.9%	1.0%	.5%
N Phys.	1,342	43	1,385	1,469	885	2,353	172	791	964	626	247	4,190	1,390	1,066	2,456	646	973	1,619	4,075	9,650
Share of Phys. & Ast.	13.9%	.4%	14.3%	15.2%	9.2%	24.4%	1.8%	8.2%	10.0%	6.5%	2.6%	43.4%	14.4%	11.0%	25.5%	6.7%	10.1%	16.8%	42.2%	100.0%

National Patterns of Enrollment, by Institutional Typology :
Freshmen Declaring Prospective Majors in Physics (and Astronomy)
1975, 1979 and 1984

Summary Table

Change in Physics	2-Year Colleges			4 - Year Colleges									Universities							
				Public			Private Non-Sectarian			Priv. Sec.			Public			Private				
	Public	Priv.	2-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H&VH Sl	Total	Prot.	Cath.	4-YR. COL. TOTAL	L&M Sel.	H Sel.	Total	L&M Sel.	H Sel.	Total	UNIV. TOTAL	NATIONAL GRAND TOTAL
% .. Frosh with Physics as Major																				
1984	.3%	.2%	.3%	.3%	1.9%	.5%	.3%	1.4%	.7%	.4%	.5%	.5%	.4%	1.1%	.5%	.6%	2.9%	1.3%	.7%	.5%
1979	.3%	.2%	.3%	.4%	1.8%	.6%	.3%	1.4%	.8%	.5%	.3%	.6%	.5%	.8%	.6%	.9%	3.2%	1.7%	.8%	.5%
1975	.2%	.1%	.2%	.5%	1.7%	.7%	.3%	1.6%	.8%	.6%	.5%	.7%	.6%	1.7%	.8%	1.1%	3.4%	1.9%	1.0%	.5%
% Change :	53.6%	147.1%	53.8%	-47.2%	9.0%	-31.5%	-1.9%	-9.5%	-20.0%	-33.0%	.6%	-26.4%	-28.5%	-35.0%	-27.6%	-45.5%	-14.3%	-28.4%	-26.1%	-12.4%
Share of Physics Market																				
1984	20.3%	1.9%	22.2%	10.6%	10.8%	21.4%	2.9%	8.5%	11.3%	4.8%	3.2%	30.7%	11.2%	10.0%	21.3%	4.9%	10.9%	15.8%	37.1%	100.0%
1979	21.1%	1.4%	22.5%	14.5%	9.9%	24.3%	3.1%	7.8%	10.3%	5.7%	1.9%	42.8%	12.7%	6.5%	19.3%	5.7%	9.7%	15.5%	34.8%	100.0%
1975	13.9%	.4%	14.3%	15.2%	9.2%	24.4%	1.8%	8.2%	10.0%	6.5%	2.6%	43.4%	14.4%	11.0%	25.5%	6.7%	10.1%	16.8%	42.2%	100.0%
% Change :	46.3%	326.8%	55.0%	-30.5%	17.9%	-12.3%	60.4%	3.4%	13.6%	-26.6%	25.3%	-6.3%	-21.9%	-9.4%	-16.5%	-26.7%	8.2%	-5.7%	-12.2%	.0

Sources: "The American Freshman: National Norms for Fall, 1984"
Astin, Green, Korn and Maier, American Council on Education, 1984
"The American Freshman: National Norms for Fall, 1979"
Astin, King and Richardson, American Council on Education, 1979
"The American Freshman: National Norms for Fall, 1975"
Astin, King, and Richardson, American Council on Education, 1975

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Appendix B: The 20 Universities with Highest-Rated Graduate Programs According to the National Academy of Sciences Rankings.

1. Massachusetts Institute of Technology
2. Harvard
3. UC - Berkeley
4. Stanford
5. California Institute of Technology
6. Yale
7. Chicago
8. Princeton
9. UCLA
10. Michigan
11. Columbia
12. Cornell
13. Wisconsin
14. Illinois
15. Pennsylvania
16. Texas - Austin
17. Carnegie-Mellon
18. Washington
19. UC - San Diego
20. Brown

Source: Astin, Alexander W., Achieving Educational Excellence: A Critical Assessment of Priorities in Higher Education, (Jossey-Bass Inc., San Francisco, Ca., 1985).

EDUCATING AMERICA'S SCIENTISTS

EXECUTIVE SUMMARY

The report prepared for the Oberlin Conference on "The Future of Science at Liberal Arts Colleges," held on June 9-10, 1985, establishes that the nation's leading liberal arts colleges rank at or near the top of all American institutions of higher education -- including public multiversities and private research universities -- in the training of scientists. And whereas universities have seen a precipitous erosion of student interest in science in the past seven years, the leading liberal arts colleges continue to sustain student interest in science at or near former levels in all disciplines. This record of achievement is due significantly to one-on-one teaching by senior scientists and to the close link between teaching and research that prevails on such campuses. Finally, the liberal arts colleges' leadership in science has been financed mainly by the institutions themselves; federal support for science at these colleges has dropped sharply even while federal funding for university-based programs has been maintained.

The highlights of the report are these:

** Collectively these scientifically-active colleges have sustained a remarkable record in attracting and educating many of the most talented undergraduate students of science, both men and women. This record is unparalleled; it exceeds that of any other group of institutions, including the more widely recognized Ivy League schools and other research universities. This record extends to all fields of science.

* While there has been significant recent erosion in freshman interest in all disciplines of the basic sciences, a trend which has affected all sectors of higher education including the top research universities, the leading liberal arts colleges have more than held their own. They have increased their share of the nation's freshman scientists. Their importance to the preparation of America's scientists is steadily growing.

* Nationally, 7% of all bachelors degrees are now awarded in the basic sciences, down from 9% in 1975, and total numbers have fallen 17% since the mid-1970's. Among the leading liberal arts colleges, however, the proportion in science has remained a constant 24% of the total, more than three times the national percentage, and nearly double the 14% proportion at the 20 leading research universities. And numbers of science graduates from these leading colleges have risen 16% over the period of study. Again, the importance of these colleges to American science is significant and growing.

* A higher percentage (8.2%) of graduates of the leading liberal arts colleges go on to earn the doctoral degree than do graduates of either the Ivy League schools (7.4%) or the 20 leading research universities (6.9%).

* Among the principal reasons for these impressive statistics is the increased number of women interested in science; women now form a majority of science graduates at the leading liberal arts colleges.

** Personalized instruction by senior scientists and widespread student involvement in research are the primary distinguishing features of these institutions, and account for their record in both attracting and producing young scientists.

* The opportunity to sustain an active research program attracts a university caliber faculty to these undergraduate colleges. Members of such faculties conduct research and publish their findings; 60% have averaged one article published in each of the last five years.

* These productive scientists teach students at all levels of the curriculum, from the introductory courses to research apprenticeships.

* Students are actively engaged in scientific research. Of the 6,961 articles that emerged from the science faculties of the institutions represented at this conference over the past five years, 1,899, or nearly 30%, were jointly authored by students and faculty.

** Driven by necessity, these colleges have made substantial investments of their own in educating scientists, and do so in a highly cost-effective fashion.

* The leading liberal arts colleges produce 6% of the nation's basic science undergraduate degree recipients, yet receive less than 0.5% of the National Science Foundation's expenditures. Corporate and foundation funding of science is also concentrated increasingly in the major research universities.

* Worse, enrollment and funding are moving in opposite directions. Proportionately, science enrollment at the leading liberal arts colleges is increasing, while their NSF funding is decreasing.

** The rate of investment required to sustain and enhance scientific enterprise at these leading liberal arts colleges must double over the next five years. Without such an investment, this source of America's scientific leadership will be imperilled.

* Such support must come from government (especially the NSF), corporations, and foundations. The only alternative is to increase tuition to an unacceptably high level.

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